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SURGERY

ITS PRINCIPLES AND PRACTICE

BY VARIOUS AUTHORS

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SURGERY

KEEN

SURGERY

ITS PRINCIPLES AND PRACTICE.

CHAPTER XXIII.

DISEASES OF THE BONES.

By Edward Hall Nichols, M.D.,

BOSTON.

In order to understand the character of the lesions produced in the bones by various pathologic causes it is necessary to have a clear idea both of the development and of the histologic and gross structure of the bones. Embryologically, some of the bones are formed practically directly from embryonal connective tissue, without any intervening cartilage, and this method is the one which occurs in the development of the bones of the skull, the so-called "membranous bones." Practically all the bones of the body except the bones of the skull are, however, preformed in cartilage, which is derived from the embryonal connective tissue. The transition of this embryonal cartilage into true bone begins usually in the middle of the cartilaginous shaft, and by a very complicated process extends in either direction toward the ends of the cartilage, so that the main portion of the shaft is converted into bone, while the two ends still persist as hyaline cartilage. At a later period one or more centers of ossification may appear in the cartilaginous ends, and by the same method of transformation that is seen in the shaft the greater portion of these cartilaginous ends may also become bone. The only portion of the bone which then remains cartilaginous is the articular cartilage, with also a thin line which separates the ossifying shaft from the ossifying cartilaginous end. The place where this thin cartilaginous line is in contact with the ossified shaft is the part of the bone where growth is most active, and is spoken of as the "epiphyseal line." At birth some of the bones show fairly well-advanced ossification, while other bones, notably the short bones of the carpus and tarsus, are still entirely cartilaginous, and the transformation into true bone takes place only at a later period.

Structure of Bone.—Taking a typical long bone at birth as an example, the bone is composed of a bony shaft with cartilaginous ends in which may appear centers of ossification. The bone is surrounded by a layer of specialized connective tissue, the periosteum. The outer layers of the periosteum are composed of dense fibrous tissue, while the deeper layers are composed of one or more layers of polygonal cells which have the function of forming bone ("osteogenetic layer"). These cells are polygonal in outline, and produce a homogeneous intercellular substance. Some of these osteogenetic cells may be included in the homogeneous material and become converted into stellate true bone-cells, while the other periosteal cells move outward and continue to deposit concentric layers of the homogeneous lime-bearing material. Thus all increase by the bones in diameter is due to the deposition of bone produced by the activity of the osteogenetic layer of the periosteum.

Beneath the periosteum comes a dense shell of bone, the so-called "cortex," composed of successive layers of true bone laid down by the periosteum. This cortex is made up of concentric layers of homogeneous intercellular material, between the layers of which appear stellate irregular spaces, the "bone lacunæ," in which lie the true bone-cells or "bone corpuscles." These lacunæ connect with adjacent lacunæ by minute canals (canaliculæ) in which lie protoplasmic processes of the bone corpuscles. In the cortex, too, are seen the circular, tubular openings in which lie blood-vessels and nerves, the so-called "Haversian canals." Inside the cortex of the shaft of the bones is the marrow, the character of which varies with different ages. In children at birth and up to about the age of fifteen this marrow is red and extremely vascular, and is composed of connective-tissue and endothelial cells which support and inclose blood-vessels, and of blood-forming cells of different varieties. As adult life approaches the marrow becomes yellow and softer, the blood-making cells very largely disappear, and the marrow is filled chiefly with fat-cells, producing the "yellow marrow" of adult life, which has a characteristic color and appearance. In old age this fat-marrow is mostly replaced by myxomatous connective tissue.

Extending into the marrow, particularly at the ends, is a bony meshwork arising from and connected with the inner surface of the cortex, which forms a supporting bony framework surrounding irregular marrow spaces—"areolar spaces." This framework adds strength to the bone and serves to give support to the marrow. This irregular framework of bone is composed of bone beams, "trabeculæ," which have essentially the same structure as the bone cortex. The spaces included by these trabeculæ are irregularly cellular in outline, but the areolar spaces do not resemble the cells of honeycomb (which is composed of *closed* polygonal cavities), but extend in a very irregular way without forming definite closed cavities. This is shown by the fact that if colored fluid be introduced into the marrow spaces at one end of a bone the fluid can enter into and fill all the spaces.

Lining the marrow canal and extending over all the irregular bony trabeculæ as a layer of specialized connective tissue is the "endosteum," which has the same osteogenetic function for the inner surface of the cortex as the periosteum has for the outer. Under normal conditions it may be difficult or impossible to demonstrate the presence of this endosteal layer, but under certain pathologic conditions, *e.g.*, after fractures or acute inflammation, etc., this endosteal layer becomes markedly thickened, and in histologic structure closely resembles the osteogenetic layer of the periosteum.

At the line where the shaft comes in contact with the epiphyseal line, as has been stated, the growth of the bone is most rapid, and it is at this line that the transformation from cartilage into bone is most active. The method of transformation from cartilage into bone is a very complicated one, and takes place in the following way: The cells in the cartilage next to the bone become very large ("hypertrophied layer") and have a columnar arrangement, with the columns arranged at right angles to the epiphyseal line. Above these hypertrophied cells the cartilage cells are smaller and are arranged in masses separated by spaces of fibrous cartilage, the so-called "proliferating layer." Above this zone the cartilage is hyaline in character and composed of single or small groups of cells separated by hyaline cartilage. The transformation of cartilage into bone takes place at the point of junction of the hypertrophied cells with the marrow spaces. The cartilage matrix between the hypertrophied cells becomes fibrillated, and in this fibrillated matrix ultimately are deposited minute granules of lime, thus forming the so-called "provisional zone of calcification." As the process continues the marrow spaces of the shaft extend into the spaces between these provisional, calcified, cartilaginous masses. The hypertrophic cartilage cells become converted into bone corpuscles, just as in the callus in fractures. The provisional calcified matrix is partly absorbed, while remnants persist as the basis of new bony trabeculæ. About these trabeculæ appear bone-forming cells (osteoblasts) which are derived partly from the endosteum of the diaphysis and partly from transformation of the cartilage cells into bone-forming cells. These osteoblasts deposit successive laminæ of new bone about the remnants of the calcified matrix. Into the space between such trabeculæ grow marrow-cells derived from the marrow of the diaphysis. In this way the layers of the epiphysis which lie in proximity to the diaphysis are constantly converted into new bone, and the diaphysis is increased in length. The gross appearance produced by these histologic changes is characteristic and distinct. The hyaline cartilage is translucent. The layers of the proliferating zone are somewhat bluer, and the hypertrophied zone makes a narrow, clear space which extends in a straight line across the shaft of the bone, at right angles to its long axis. Below the clear space of the hypertrophied zone comes a narrow white line (line of provisional calcification), which is parallel to the base of the epiphysis.

Surrounding the diaphysis and the epiphysis is a layer of dense fibrous tissue (periosteum or perichondrium). The deeper layers of the periosteum consist of polygonal cells, similar to the osteoblasts of the marrow, which have the power of forming bone. These periosteal osteoblasts deposit successive layers of dense bone on the outer surface of the cortex of the diaphysis, and thus increase the diameter of the bone. This process, if not modified, ultimately would lead to an excessive amount of cortical bone, and to prevent this there is a constant absorption of the inner layers of the cortical bone already formed ("lacunar resorption"). This absorption is effected by the giant-cells (osteoclasts) of the marrow. Thus, by simultaneous deposit of periosteal bone and absorption of the inner layers of the cortical bone, the thickness of the cortex always remains relatively the same.

The structure of bones is a beautiful mechanical adaptation to its functional needs, and practically bone is so arranged as to give the greatest possible amount of strength commensurate with size and light-ness. The general impression is that the adult bones are fixed quantities, but that is not exactly the fact. The shape of the bones depends upon two things—partly upon heredity and partly upon function. Bone under pressure may entirely alter its shape, as seen in the most marked degree in Chinese ladies' feet, but some alteration of shape is constantly going on in the bones both under normal and under diseased conditions. This alteration of shape is brought about not by direct bending, but by a constant oscillation between the new formation of bone by osteoblasts and periosteoblasts, and the constant absorption of bone by the osteoclasts. Even when the conditions under which the bones do their work do not alter, there still is a constant new formation and resorption of bone going on, although it may be to a very slight degree. The arrangement of the trabeculæ in normal bone is such as to take up weight to the best possible advantage, and the trabeculæ are arranged in a general way like the lines of "stress and strain" in a derrick designed by a skilful engineer.

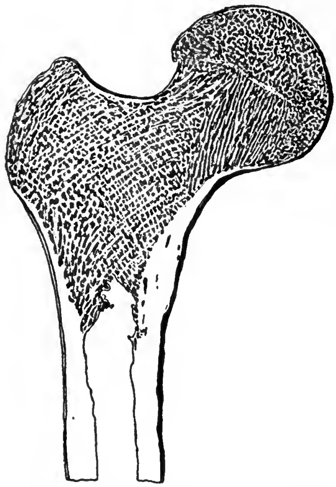


Fig. 1.—Vertical Section through Head and Neck of Human Femur.

Shows the peculiar arrangement of the trabeculæ in lines of "stress and strain." Dried specimen.

Methods of Examination.—Mere inspection of the bone will at times give valuable information as to the pathologic condition, gross changes in shape or in size oftentimes being visible, especially in bones which are not covered by a thick layer of muscle. By palpation of bones, however, much more accurate information can be obtained as to differences in contour or in diameter of the bone, either throughout the entire shaft or in localized areas, or as to increased density. Measurement of the length of bones is an accurate method of determining many pathologic changes, although it must be borne in mind that even under normal conditions there may be slight variation in the length of corresponding bones on the two sides. The legs, for instance, often show a variation of half an inch with no impairment of function. It should also be borne in mind that even in expert hands it may be impossible to measure corresponding bones in the same individual without an error of observation of a quarter of an inch. Since the introduction of the x-ray, the most valuable method of examination of the bones has come into play. But the more the x-ray is used, the more apparent it becomes that the interpretation of x-ray photographs is a difficult matter. The x-ray detects only differences in density. To be able intelligently to interpret the x-ray photographs one must have a very accurate knowledge of the pathologic processes which may produce diseased bones. With an appreciation of the very numerous causes which may lead to a difference in density, it is true that in many typical lesions inspection of the x-ray photographs alone may be sufficient to make an accurate diagnosis, but in such cases the employment of the x-ray often is not necessary. In cases in which the clinical diagnosis is difficult the x-ray examination is simply one of several means which must be employed, each of which must be given its relative value as a method of diagnosis. In some cases not only is diagnosis by the x-ray difficult, but the x-ray examination may be absolutely misleading. In other words, the x-ray is an enormous advantage in the diagnosis of lesions of bones, but its value has been greatly overestimated, and the possibility of its giving an entirely erroneous impression must not be overlooked, especially in medico-legal cases. In many cases of obscure bone lesion the diagnosis can be completed only by an exploratory incision into the diseased bone. In that way may be recognized areas of softening produced by bone abscesses, or by the growth of malignant tumors, or by the presence of cysts, or by areas of tuberculous softening or softening due to gummata. The areas of increased bone density seldom show on exploratory incision any evidences which increase our ability to make a definite clinical diagnosis, because around practically all areas of diseased bone, no matter what the origin of the lesion may be, is a zone of bony thickening and increased formation of trabeculæ, with myxomatous or fibrous marrow in the areolar spaces, which the pathologist calls only "chronic inflammation," without, as a rule, having any knowledge which leads to the determination of the particular *cause* of the inflammation.

The lesions of bones may be divided practically into four classes: 1. Those lesions produced by various pathogenic organisms, including those pyogenic organisms which ordinarily cause acute suppuration, and the organisms of tuberculosis, actinomycosis, and syphilis. 2. Those lesions which are apparently due to some diathesis, and which affect practically all or many of the bones of the skeleton; the actual cause of most diathetic diseases is absolutely unknown. They include osteogenesis imperfecta, chondrodystrophia fœtalis, osteitis deformans, rickets, osteomalacia, and acromegaly. 3. Changes in the bone produced by disuse—atrophy. 4. Tumors of bone. 5. Cysts, which may be primary or may be due to the presence of echinococci.

CONGENITAL DEFECTS OF BONES.

The limbs of the mammalian body represent a persistence of specialized parts of the lateral fin-fold, which is seen in some of the lower fishes. This lateral fin-fold is in many respects similar to the dorsal and ventral fin-fold of fishes. In the higher animals this fin-fold becomes shorter and freer, and presents not only an upper and a lower surface, but an anterior and a posterior border. The primitive skeleton of such fins has a bar of bone at the base of the fin, from which lateral rays run out into the fin. In the higher fishes these lateral rays extend off from either side of the skeletal limb. Such a limb is the ancestral type of the limb of mammalians, including man. In man each limb is divided into four segments, and consists of a single upper bone (humerus or femur), the two bones of the forearm, or of the lower leg, then nine bones of the car-

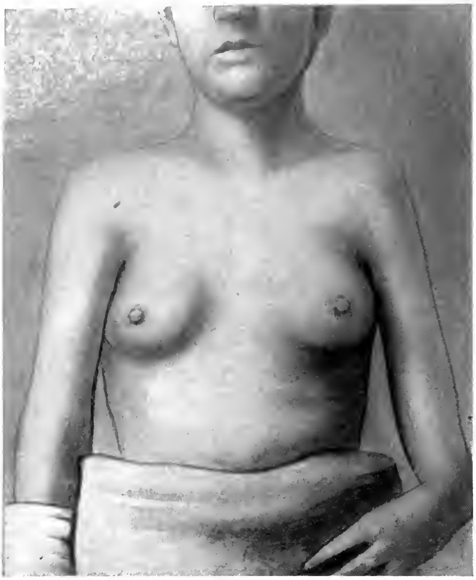


Fig. 2.—Congenital Absence of Radius in Girl of Seventeen (Lund).

pus, or tarsus, and the hand, or foot. In human beings these bones are all preformed in cartilage in the embryo; later, by a process of ossification which has already been described, these cartilaginous provisional tissues are converted into true bone.

Various congenital deformities of the limbs occur in man because of interference in various ways with the proper and normal formation of these cartilaginous masses. If, for any reason, the cause of which in most cases is not clear, any of these cartilaginous masses fail to be preformed in the embryonic tissues, naturally no ossification can occur, and in such cases there may be a partial or complete lack of development of the corresponding bone. The amount of this congenital absence may vary from the absence of an entire hand (acheiria) to the absence of one or several digits (ectrodactylism) or of one or more phalanges (hypophalangism). The deformities produced by such a failure to deposit the cartilaginous base of the bones are very numerous; may affect any of the bones of the body, and in some cases lead to great deformity and loss of function. If, on the other hand, instead of a failure to preform the necessary cartilaginous masses for the development of bones there is a deposit of an unusual number of cartilaginous masses, representing a reversion to the condition present in some of

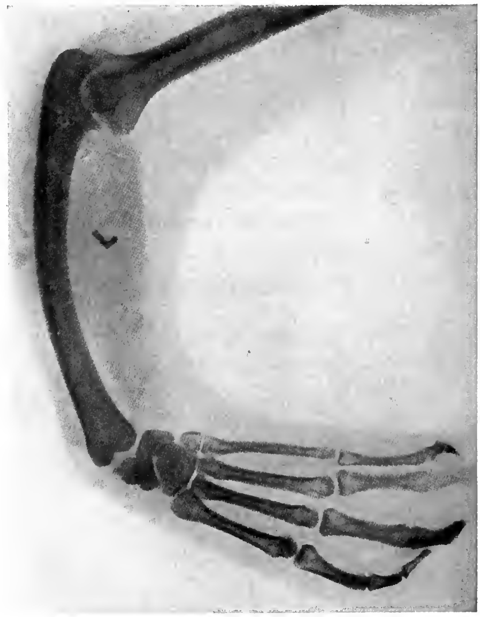


Fig. 3.—Skiagraph of Left Arm from a Case of Congenital Absence of the Radius (Lund).

the lower animals, *i. e.*, if too many rays are laid down in cartilage, it is possible for extra bones to be formed. The extent to which this condition occurs also is very variable, and may lead to the formation of extra hands, fingers, phalanges, or limbs (polydactylism, etc.). The most common form of this deformity is the appearance of an extra digit, which most often appears in the form of an extra or bifid thumb. When extra bones are formed, there is apt to be, in addition, a perversion of development of these extra bones, resulting in all sorts of extraordinary combinations of digits, etc., producing the deformities known as syndactylism, cleft hand, together with many varieties of congenital dislocation. In many of these cases there also is a webbing between adjacent digits, due perhaps to a reversion to some of the ancestral types with webbed limbs (Figs. 4 and 5).

Fig. 4.—Polydactylism.

Fig. 5.—Skiagraph of Polydactylism.

This lack of or increase of the preformation in cartilage results in most extraordinary deformities. No special type of deformity merits

FIG. 6.—SYNDACTYLISM (Lund).

special attention. The condition in each case must be decided by inspection and by x-ray examination. In many of the cases, especially

FIG. 7.—SKIAGRAPH OF SYNDACTYLITIC HAND (Lund).

where the lesion affects the digits, the capability of the individual is but little impaired. In other cases, where bones are absent, marked deformity and impairment of function may occur. Some of the cases, notably webbed fingers, are comparatively easily corrected. (See p. 572.) Other cases, however, offer little chance of sufficient cosmetic or functional gain to make a surgical operation necessary or desirable.

ATROPHY OF BONE.

Various causes may lead to atrophy of bone. The method by which atrophy is brought about is peculiar, and is due to the action of special giant-cells called osteoclasts. Wherever extensive atrophy of bone takes place, microscopic inspection shows such giant-cells lying closely applied to the trabeculæ of the bone which is being resorbed, and the trabeculæ in that immediate vicinity slowly disappear under the action of these giant-cells. Their action is very similar to the action of giant-cells in the soft tissues about absorbable foreign bodies. This process is called "lacunar resorption." In old people the amount of absorption oftentimes is very great, and in that case the process is termed "senile atrophy." It may be marked in the skull and in the long bones, and in many of the cases of fracture of the neck of the femur a moderate amount of lacunar resorption precedes the fracture which results from slight violence. In certain cases this resorptive process in old people is extreme, and leads to great fragility of the bones, with repeated fractures from slight violence which, under ordinary circumstances, would cause no injury at all.

A mere lack of use of bones also may lead to a certain amount of atrophy from lacunar resorption. This may be seen after amputations, *e. g.*, where the stump of bone which is left from the amputation slowly undergoes lacunar resorption and sometimes a marked diminution in size. The same thing may be seen also in the bones of people who for long periods of time are deprived of the use of their limbs, either from the application of apparatus, *e. g.*, around fractures, or from disuse for other reasons.

Lacunar resorption also occasionally follows lesions of the central nervous system, part of the atrophy being due to disuse of the limbs from the paralysis, and part of it also being dependent in some indirect way upon the nerve lesion. Atrophy of bone also may be brought about by pressure. It is to be remembered that the bone, as a matter of fact, is not a perfectly rigid material, but that processes of new formation and resorption are constantly taking place even under normal conditions. If, for any reason, bone is put under constant pressure, a certain amount of readjustment of the bony constituents takes place in order to adapt the bone to its altered condition. The most striking example of this sort of atrophy is perhaps the Chinese ladies' feet, where the bones, being bent into an abnormal position beginning early in childhood, ultimately show enormous deformity and an entire rearrangement of the trabeculæ of the bone. The same thing also may be seen occasionally after pressure and deformity from contracture of muscles or from the pressure of scars. This process, which ordinarily leads to loss of function, in a certain limited number of cases aids function, *e. g.*, certain fractures of the joints may lead to deformity of the articular facets of those joints, but by absorption of certain portions and new formation in others, a readjustment of the joint surface may take place, so that a marked increase of function may occur. A certain amount of atrophy also may be brought about by the pressure and development of tumors.

HYPERTROPHY OF BONE.

In many cases new growth of bony tissue is due to the new formation of periosteal bone, and is an expression of an attempt at repair of one or the other of the numerous destructive processes. In other cases true hypertrophy of the bone, with no connection with any reparative process, may occur. A notable example of this is seen in the growth of bone which sometimes occurs after amputation, especially in young people. The increased size of the bones which is seen in many definite diseases will be mentioned under the proper headings.

CARIES AND NECROSIS.

Various pathologic processes produce destruction of bone. The destructive process may cause the death of large areas of the affected bone at once, and in that case a large fragment of necrotic bone may remain *in situ* and still maintain its contour. Destruction of bone of this sort is described by the clinical term *necrosis*. Other processes cause a gradual molecular softening and destruction of bone, which ultimately may be very extensive, but at no time is there present any appreciable large mass of bone. Destruction of this sort is described by the clinical term *caries*.

As a means of differentiating clinical conditions, the use of these two words is desirable. As a clinical term, necrosis usually means destruction by pyogenic infection, and caries usually means destruction by the gradual extension of a tuberculous process. This clinical distinction, however, is not an exact one, because destruction of large areas of bone, *i. e.*, necrosis, is occasionally brought about by syphilitic infection, and rarely by tuberculosis, and molecular destruction of the bone is brought about by a considerable variety of processes, the chief of which, it is true, is tuberculous infection; but actinomycosis and syphilis may both lead to the gradual disintegration of the bone without the formation of large necrotic masses of bone.

The presence of necrotic bone connected with the surface by sinuses, from which comes a discharge of pus, should always lead to the consideration of tuberculosis, actinomycosis, and syphilis. The presence of large sequestra of bone should immediately suggest the presence of osteomyelitis or of syphilis.

Treatment.—The details of the treatment of the various forms of destructive processes in bone will be found under their special headings, chiefly under Osteomyelitis and Tuberculosis. In all the cases of caries it is desirable to remove completely the softened areas in the bone. This may be done by curettage and drainage or by excision of the entire bone or series of bones in certain cases, or rarely by amputation. The difficulty in all these cases is to recognize the exact limits of the carious process. It must be borne in mind that at the time of operation upon carious bones the field of vision of the surgeon is almost always limited; moreover, the bleeding which always takes place from the bone-marrow in such cases also obscures the field, and even if these two causes were not present, it is frequently extremely difficult, by naked-eye examination, to determine the exact limits of the destructive process. As a general rule, it can be said that the carious area is at least a quarter of an inch wider than appears upon visual inspection.

In cases of necrosis with large bone defects the difficult thing is to cause a growth of the bone toward the central cavity after removal of the sequestrum. The various methods applicable to such cavities are mentioned in detail under Osteomyelitis.

PERIOSTITIS.

Acute Periostitis.—The older text-books always laid great stress upon the occurrence of an acute infectious inflammation of the periosteum. In my opinion, acute suppurating periostitis alone does not occur, and most of the cases which have been described as such are really mild cases of superficial osteomyelitis, with abscess formation beneath the periosteum, and possibly slight inflammation of the periosteum itself. These cases ordinarily lead to only a slight destruction of the outer layer of the cortical bone. The symptoms are the same as in acute osteomyelitis, except in a very much milder degree. There usually is a rise of temperature, oftentimes with a chill, with circumscribed tenderness over some portion of the shaft of one of the long bones. Incision over such an area shows an elevated periosteum, with a small, localized abscess beneath it, with bare white, somewhat vascular bone-cortex. Incision alone in most cases suffices to cure the disease, although if the process has extended sufficiently deep to cause a superficial necrosis of the outer layer of the cortex, removal of a small sliver of necrotic bone may be necessary.

Chronic Periostitis.—A long-continued and chronic irritation of the periosteum sufficient to cause a proliferation of the osteogenetic cells of the periosteum is common in a great many diseases. A chronic thickening of the periosteum with a new formation of bone is seen frequently after traumatism, blows, or contusions; sometimes after the occurrence of superficial abscess of the soft tissues in the immediate vicinity of the shaft of the long bone, *e. g.*, a chronic ulcer of the surface of the tibia, or after certain infectious diseases, notably syphilis. It also may occur after various other local infections. In such cases the thickening of the periosteum ordinarily is pretty sharply localized. A general thickening over the periosteum, over several or many of the bones of the body, also occurs in the disease known as toxic osteoperiostitis ossificans, seen in diseases with long-continued suppuration. It also is common after syphilitic disease, either congenital or acquired.

Symptoms.—The symptoms of chronic periostitis with new formation of bone are very variable. In a certain number of cases there is a constant heavy, dull pain at the point of thickening, with at times more or less acute exacerbation; at other times the lesion is associated with no

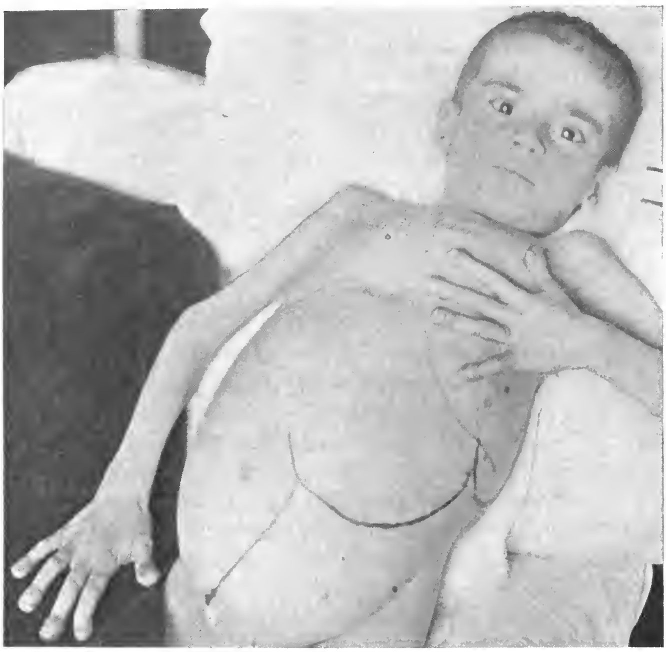


Fig. 8.—Toxic Osteoperiostitis Ossificans (Pulmonary Hypertrophic Osteo-arthropathy).
Case of Pott's disease, with amyloid liver and spleen. The clubbing of the fingers is most marked.

pain whatever, and the patient's attention is first called to the disease by the presence of bony enlargement. Or recognition of the condition may depend upon x-ray examinations for indefinite pains in or over the bone.

Chronic periostitis is not really a distinct disease itself, but a manifestation of the reaction of the periosteum to some irritant.

Treatment of the condition depends, first of all, upon a recognition of the cause and a removal of that cause, when possible. In many cases, especially those in which no pain is present, nothing in the way of therapeutic measures can be done. The chronic thickening of the periosteum seen in many definite bone diseases will be mentioned under those diseases.

OSTEOMYELITIS.

Infectious osteomyelitis is acute suppuration of the bone, and always is due to the infection of the bone-marrow by pyogenic microörganisms. The process is essentially like the process seen in the furuncle, and has been graphically described as "bone furunculosis," although the process in the bone is somewhat modified by the peculiar anatomy of the tissue in bone. The process begins in the marrow of the alveolar spaces, which communicate freely with each other, but which are inclosed by a dense shell of cortical bone. Hence the process at first may quickly involve the entire marrow of an infected bone, because the products of bacterial infection are retained in this dense shell, while the primary focus only can be reached by extensive bone operation.

Etiology.—The direct cause of infectious osteomyelitis always is an infection by some pyogenic bacteria. In the vast majority of cases the organism is the staphylococcus pyogenes aureus. In a few cases it is the streptococcus. In other cases the pneumococcus is the cause of the lesion. The character of the infecting organism cannot be determined either by clinical symptoms or by the pathologic changes produced, although the streptococcus has a greater tendency to extend into and infect the joints and to cause a superficial infection of the bone and produce a periostitis rather than a diffuse osteomyelitis. Such streptococcus infection often occurs in infants from mothers suffering from septicemia, and may be due to infection during delivery.

Not infrequently the typhoid bacillus may cause suppurative processes in bone. As a rule, such infections produce lesions of small extent which are superficial, and the destruction of the marrow is slight unless a secondary infection with some pyogenic organism occurs. It generally occurs quite late in the course of typhoid fever.

As a rule, the infecting organism is present in pure culture, but sometimes a mixed infection occurs, and such cases are said to be especially severe. In cases of chronic osteomyelitis with open sinuses and exposed bones a great variety of organisms, pathologic and saprophytic, may be present. Hence infectious osteomyelitis is not a specific disease, but is acute inflammation of bone that may be produced by any one of a variety of pathogenic organisms or by a mixed infection. Any pyogenic organism which can be carried in the blood may be deposited in the bone and produce suppuration. Some of these organisms may settle by preference in the bone-marrow, others beneath the periosteum or in the joint. Some tend to act at the point of the greatest bone activity, others at points of injury.

The lesions have been produced in experimental animals by inoculating them with various pyogenic organisms.

Predisposing Causes.—Certain general causes favor the occurrence of osteomyelitis. The disease usually occurs in individuals whose bones have not attained complete development, *i. e.*, in children or adolescents, although it is not rare in adults and sometimes occurs in advanced life. About one-half of the cases occur between thirteen and seventeen, although young children often are infected. The disease is said to occur in boys about three times as often as in girls. It frequently appears after extreme fatigue or exposure to cold or wet, and occurs most frequently subsequent to the exanthemata. Osteomyelitis occurring subsequent to such infectious diseases usually is due to secondary infection with pyogenic organisms which find most favorable opportunity on account of lowered resistance produced by those diseases. Acute osteomyelitis frequently follows injuries of moderate severity, because such injuries may lower the local resistance of the bones and make them unusually susceptible to pyogenic infection. One of its commonest causes is the infection of a compound fracture, and before the days of asepsis such cases were very frequently fatal. Under modern methods the infection, when it does occur, is generally slight, although the destruction of the bone may greatly delay healing and may lead to the formation of small sequestra and indurating sinuses. Infection of a similar sort may occur subsequent to amputation.

Fig. 9.—Chronic Osteomyelitis of Many Years' Duration.

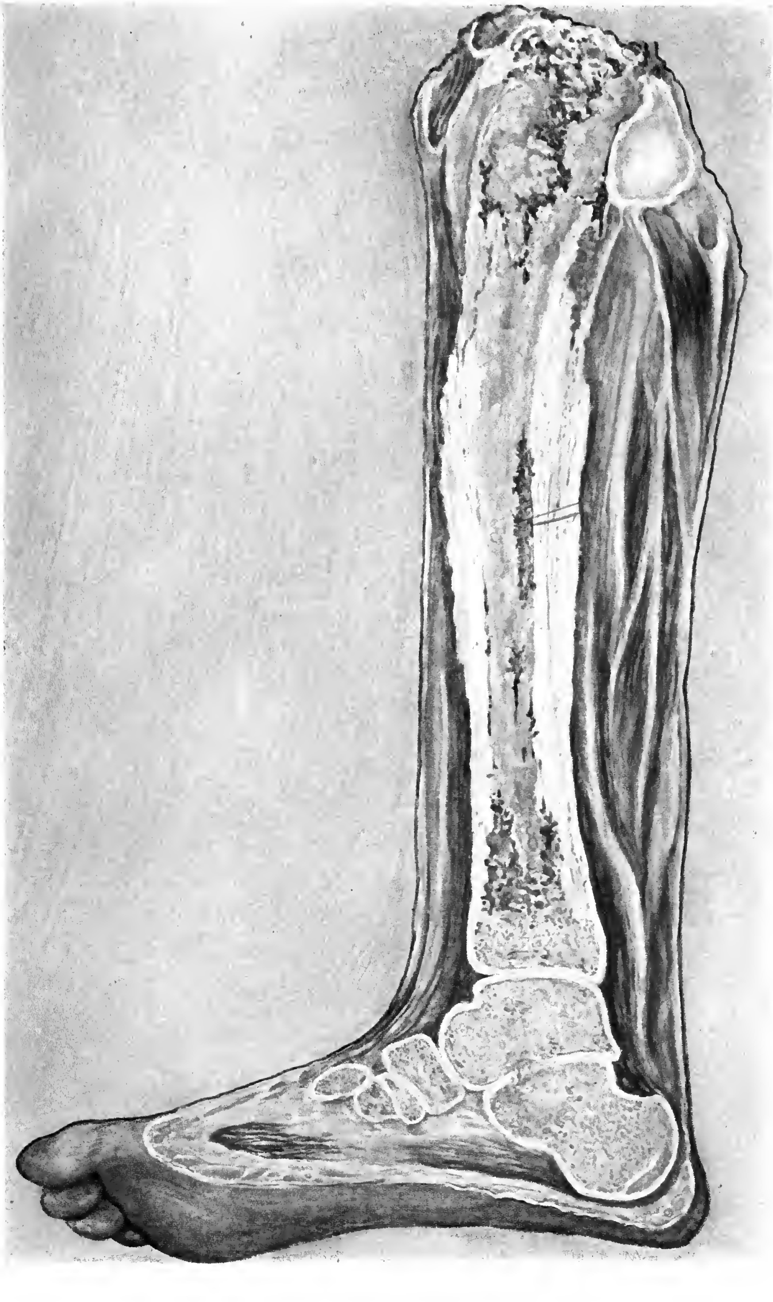
Marked thickening and ulceration of soft tissues with large sinuses leading down to necrotic sequestrum.

Infection of the bone often is secondary to a local infection in some other part of the body (*e. g.*, a furuncle or carbuncle or phlegmonous inflammation), and the infecting organisms may be carried from such a focus by the blood and cause acute suppuration of bones in distant parts of the body. In other cases the osteomyelitic focus appears to be the primary focus of the disease.

Osteomyelitis nearly always begins in the *diaphysis* of the long bones, usually near the epiphyseal line. This is an important point clinically, because tuberculosis practically always begins in the epiphysis. In rare cases, however, osteomyelitis begins in the epiphysis, and so may simulate acute tuberculosis. The femur and tibia are the bones most frequently attacked, but no bone is exempt. Usually only one bone is affected, but cases of multiple bone infections are not rare.

The primary area of infection is always in the bone-marrow. The bony trabeculæ and the cortex are destroyed only secondarily. The pro-

PLATE I.



ACUTE INFECTIOUS OSTEOMYELITIS.

Vertical section through the lower leg and foot. Marrow of the shaft of the tibia almost entirely infiltrated with greenish-yellow purulent exudate. In places adjacent to the purulent exudate are areas of injected marrow. The exudate has extended through the lower epiphyseal line into the epiphysis. The thickening of the cortex of the shaft is due to a deposit of periosteal bone. The upper epiphyseal line has been perforated, and the epiphysis is infiltrated with purulent exudate.

cess nearly always begins in the diaphysis, but then may early extend into the epiphysis and produce suppuration of the joint. Once the organisms have gained access to the marrow, they produce a toxin which causes necrosis of the adjacent marrow-cells, and this necrosis may extend over a very considerable portion of a long bone before marked infiltration with leukocytes occurs. Then comes an infiltration with leukocytes, *i. e.*, a purulent exudation, in the necrotic area. The bone, if sawed open, is mottled with numerous yellow or greenish areas of suppuration, together with reddened areas of injection and hemorrhage. Solution of the soft tissue of the marrow is usually great. Sometimes even in the early stages there is some solution of the bony trabeculæ. After the formation of definite cavities containing a purulent exudation or a "bone abscess" the infection may extend rapidly along the entire marrow canal of a long bone. The extension is always more or less irregular because of the irregular communication between adjacent marrow spaces.

Fig. 10.—Result of Operation for Acute Osteomyelitis of Femur.

Shows attitude without atrophy or shortening; scar of operation, inner side of left thigh, eight months after operation. The endosteum in this case was not curetted.

The infection usually quite early extends through the dense cortex by way of the Haversian canals, and produces an inflammatory exudation and suppuration between the periosteum and the outer layer of the cortex, *i. e.*, a subperiosteal abscess. Such an abscess may strip the periosteum from the bone over very extensive areas. The infection may then extend to the adjacent soft tissues, muscles, and subcutaneous tissue, and form an abscess outside the periosteum. Finally such an abscess may perforate the skin through one or more openings, leaving sinuses which lead down to bare necrotic bone. As a rule, the infection is confined to the diaphysis by the epiphyseal line. In some cases, especially in adults, in whom the epiphyseal line is ossified and does not persist as a definite cartilaginous wall, the infection may extend through the epiphyseal line, may involve the epiphysis, and then extend into the joint and produce acute suppuration of the joint. In some cases the process produces a separation of the shaft from the epiphysis at the epiphyseal line—the so-called "spontaneous fracture."

The cortical bone early becomes necrotic over considerable areas. The extent to which cortical necrosis occurs depends upon two things—on the amount of destruction of the endosteum and the amount of separation of the periosteum. If much of the endosteum is destroyed, a corresponding amount of necrosis of the inner layers of the cortex will occur. If much of the periosteum is stripped from the bone, a corresponding amount of necrosis of the outer layers of the cortex follows. If both the endosteum and periosteum are involved, the cortex will be destroyed throughout. Since the amount of destruction of the endosteum and the extent of the stripping of the periosteum vary greatly in individuals, the amount of necrosis of the cortical shell varies within wide limits.

FIG. 11.—SHOWS COMPLETE REGENERATION OF BONE AFTER EARLY DRAINAGE FOR ACUTE OSTEOMYELITIS.

Skiagraph of left femur, side view. Slight change of density of bone, probably at upper limit of trephine hole in cortical bone. Eight months after operation.

In nearly all cases because of the impermeability of the cortex and on account of the rapid extension of suppuration over a large area the amount of septic absorption is great, and the symptoms of toxemia are extreme.

If, from spontaneous opening of the abscess or from operation, a fatal result is avoided, the infective process may be limited and the process of repair may begin. As a rule, a portion of the infected marrow and cortex become completely necrotic, and the lime-bearing portion of the bone persists as a more or less extensive "sequestrum." Repair inside the cortex is brought about by the formation of granulation tissue which arises from the reticulum of the marrow and by a formation of new bone which is produced by the endosteum. Repair externally is brought about by the formation of new bone produced by the periosteum. Thus the periosteal new bone forms circular layers of bone which surround the necrotic remnant of the original shaft. The shaft is then known as the "sequestrum," and the surrounding shell is the "involucrum." The involucrum is attached at either end to the remnant of the original shaft which has not been destroyed by the disease. As a result of the formation of granulation tissue and the deposition of new endosteal bone the sequestrum is walled off from the sound portion of the shaft by a plug of bone which at first is soft and spongy, but which, if the process continues for a long time, becomes dense like dense cortical bone. The width of this plug varies a great deal; in cases of compound fracture it usually is narrow and forms a wall extending directly across the bone; in cases of spontaneous osteomyelitis such areas of new endosteal bone may be irregularly distributed or may form a wall surrounding and inclosing definite circumscribed areas of purulent inflammation, *i. e.*, there may be an abscess with a wall of dense endosteal bone.

Dense cortical bone has very little or no power of direct repair. The integrity of the cortex depends entirely on the vitality of the endosteum within and the periosteum without. If the endosteum is not destroyed, the internal layer of the cortical bone will retain its vitality. If the periosteum is intact, the outer layer of the cortex retains its vitality. The necrosis and inability of repair of the cortical bone are the chief causes of the persistence of sequestra and sinuses in chronic osteomyelitis. The marrow has considerable power of repair, but the cortex, if the periosteum and endosteum are destroyed, may persist as a sequestrum. It may remain indefinitely as a solid sequestrum or may be discharged entire or piecemeal. In any event it is surrounded by the involucrum of new periosteal bone, which, after a time, becomes dense bone like the cortex, with relatively small power of repair, and in such a case if the sequestrum is removed, it leaves a cavity surrounded by a shell of dense cortical periosteal bone which has not the power of central growth sufficient to close the cavity.

The involucrum is produced by the periosteum. The bone first formed by the periosteum is soft and vascular, very much like the external callus soon after a fracture. In the course of time the bone becomes harder, denser, and of a character like that of ordinary cortical bone, and this involucrum increases in size until a sufficient amount has been produced to carry on the function formerly carried on by the original shaft.

The gross appearance of the marrow of the cortex and periosteum varies with the stage of the disease. In the very earliest stages, if the marrow is opened, no discharge of pus may take place because at that time the marrow is simply necrotic, and invasions of leukocytes take place only later. At a later period the marrow shows distinct suppuration, and usually contains many large and small oil-drops, produced by disintegration of the fat. A failure to get a purulent discharge of pus from the marrow is, however, not necessarily evidence of absence of osteomyelitis in very early cases.

The cortex at first when stripped of periosteum is white and shiny, and often shows minute red vascular spots. At a later stage the bone appears white, opaque, without luster, and after the bone has persisted for some time as a definite sequestrum, it may become brown or blackish.

The periosteum in the early stages may be separated from the bone by a collection of pus, and in such cases it appears as a thin, fibrous membrane beneath the muscles separated from the bone by the abscess cavity. In the course of a few weeks—from eight to twelve—the periosteum becomes thicker, and in the deeper layers a thin shell of bone is formed, which crackles under the fingers, or if it is perforated by a needle or other sharp instrument, crackles like hoar-frost on a cold morning. Still later the periosteum forms a distinct shell of bone surrounding the necrotic sequestrum, and this shell increases in thickness until its total diameter is as great as the diameter of the original shaft or even greater. Under such conditions it forms a cylindric shell about the sequestrum, attached at either end to the remaining portions of sound bone.

Extending across the sound portions at the point of attachment of the periosteum shell or involucrum is a dense wedge of eburnated bone. If, instead of a definite sequestrum being formed, a localized bone abscess is produced in the shaft, this bone abscess also is surrounded by a wall of dense eburnated bone. Such abscesses were originally described by Sir Benjamin Brodie, and for that reason they are often called "Brodie's abscess." They often are found in the vicinity of the epiphyseal line, especially of the tibia, femur, and humerus. They usually cause a great deal of localized, deep, burning pain, with tenderness but without much swelling, and often no discoloration. The only treatment is evacuation by trephining the bone and packing the cavity until it fills up. Relief of the pain is immediate.

FIG. 12.—OSTEOMYELITIS WITH REMOVAL AND REGENERATION OF TIBIA.

Skiagraph. Removal of lower third of left tibia twice. Lateral view. Nine months after first removal of bone.

Areas of localized softening in bone which are not surrounded by a dense wall of bone usually represent gummata of syphilis and not abscesses the result of osteomyelitis.

Secondary changes occur in the soft tissues surrounding the seat of an acute suppuration of bone. During the acute stage there may be a definite abscess of the soft parts, with an infiltration which simulates phlegmonous inflammation, or, by rupture of the abscess, various sinuses may be formed leading down to the necrotic foreign body. In long-continued cases the skin and subcutaneous tissue become thickened by the formation of scar tissue due to the presence of the involucrum and the persistence of sinuses; and by thickening of the soft tissues an affected limb may for years be nearly twice normal size.

Symptoms.—The disease commonly begins with a sharp onset, the first symptom usually being a sudden localized pain in the vicinity of the epiphyseal line or in the shaft of some one of the long bones. This pain is extremely intense, and in typical cases is more violent than any other pain with which I am familiar. Motion of the joints at this time often is not painful, but the pain produced by percussing the bone, even lightly, may be intense. An extremely valuable diagnostic point is continued *gentle* pressure at some point over the shaft of the bone at a distance from the point of greatest constant pain. At first such gentle pressure produces no re-

PLATE II.

1

2

SUBACUTE INFECTIOUS OSTEOMYELITIS OF THE TIBIA. FRONT AND REAR VIEWS.

The plate shows the tibia from the upper epiphyseal line to about the middle of the shaft.

1. Shows the portion of the original tibial shaft, necrotic, injected, or infiltrated with purulent exudate encased in the roughened and irregular periosteal involucrum.

2. Is the same portion of the tibia seen from behind and demonstrates that the roughened involucrum is continuous with the uninfected shaft.

action at all, but after a moment, very suddenly, the pain becomes extremely severe, and the patient will cry out or suddenly sit up.

Usually at a very early period there appears swelling of the soft parts about the bone. This swelling at first is neither hot nor red, but soon becomes edematous, red, and shows pitting on pressure, and at that time may simulate acute phlegmon. In some cases the adjacent joint early becomes tender, hot, and swollen, and this may occur even when there is no real extension of the infectious process to the joint itself. If extension to the joint occurs, swelling, tenderness, and pain on motion become more intense.

The temperature usually is elevated to a considerable degree—103° or 104° F.—and usually the pulse is greatly accelerated. Evidence of constitutional disturbance and absorption of infectious material appears early. The tongue is dry, coated, and tremulous; the face is drawn and flushed. Delirium of a mild type is a very common symptom, and in some cases this delirium may persist for a considerable length of time after the bone has been drained.

Abscess of the soft parts may give deep or superficial fluctuation. Sinuses may appear. The leukocyte count usually is very high—25,000 or 30,000.

Such a clinical picture is perfectly distinct, and it is difficult to overlook typical cases, especially after fluctuation in the soft parts has occurred. But the diagnosis of early cases, however, is sometimes difficult, and even in the hands of experienced men, who have the lesion in mind, sometimes is impossible. Even in severe cases, occasionally the pain itself is not severe for several days, when there may come a sudden exacerbation of symptoms.

The pain frequently is referred to an adjacent joint, in which no gross change can be made out, or the swelling of such a joint may come on so early as entirely to distract attention from the disease in the bone until abscess appears. These atypical cases are much more likely to occur where the disease begins in one of the small short bones of the carpus or of the tarsus, and such cases frequently for days are treated as articular rheumatism. On the other hand, the general infection may be so acute and so sudden that the patient's mental condition is so dull that the pain is not noticed, and such acute cases may be mistaken for typhoid fever.

These difficulties, however, do not excuse the many frequent failures to recognize the condition, which seem often to be due to neglect to remember that *osteomyelitis is not an uncommon disease in children and young adults.*

In the chronic stages of osteomyelitis the symptoms usually are characteristic. The limb is enlarged, the enlargement being due partly to thickening of soft tissues, but chiefly to the formation of the involucrum. Running down to the sequestrum usually are enormous sinuses from which comes a foul, purulent discharge. On passing a probe, dead bone can be felt at the bottom of the sinuses. It must be borne in mind, however, that in a great many cases after attacks of osteomyelitis of moderate severity small localized abscesses are formed in the shaft of the long bones, with no sinus communicating with the surface. Such an abscess, as has already been stated, always is surrounded by a wall of dense bone, like cortical bone. Such an abscess may persist for years with no symptoms beyond a moderate enlargement of the shaft of the bone at the point of the abscess, and the enlargement may be so slight that it is not recognized by the patient. In other cases the entire shaft may be enlarged, but the bone may not be tender. In most cases, however, such a localized abscess sooner or later gives rise to recurring attacks of pain, which, as a rule, are extremely violent. The intervals between such attacks may vary from days to weeks or months or even years. The attacks of pain may come on apparently perfectly spontaneously. Associated with these attacks of pain the bone over the abscess usually is exceedingly tender to touch. With the attacks of pain may come a rise of temperature, or in some cases no disturbance of the general condition at all. Such an abscess may be of small size,—no larger than a pea,—or may involve a great portion of the shaft of the bone; and in such abscesses no definite sequestrum ever may form. The recognition of such conditions depends upon recurrent attacks of violent pain over circumscribed areas of bone, with or without constitutional disturbance, and almost always with extreme local tenderness.

Diagnosis.—The diseases most frequently mistaken for osteomyelitis are early acute tuberculosis of joints, articular rheumatism, gonorrheal rheumatism, and typhoid fever.

Tuberculosis of the joints practically always begins in the epiphysis of the long bones, while osteomyelitis almost always begins in the diaphysis. This distinction will clear up the diagnosis in many cases, although rarely osteomyelitis itself may begin in the epiphysis. In case of epiphyseal osteomyelitis the acute onset, extreme pain, the early infection of the joint, marked leukocytosis in contrast with its absence in tuberculosis, and the appearance of constitutional symptoms should permit of the diagnosis. Moreover, in epiphyseal osteomyelitis spontaneous separation of the epiphysis is said to be not uncommon. This is the cause of many of the cases of so-called acute epiphysitis.

Acute articular rheumatism, as a rule, affects more than one joint, and the symptoms are much less marked. The constitutional disturbance is less, and the leukocyte count and the temperature are very much lower. Reaction to salicylates may also help in the diagnosis. In osteomyelitis the bone pain is always more marked than the pain from motion of the joint.

Gonorrheal rheumatism may, of course, affect but one joint, and the early symptoms may be severe. The bony tenderness, however, is wanting, and the history of an antecedent gonorrhea can usually be determined. The constitutional symptoms usually are much less than in osteomyelitis; cultivation of gonococci from the joint would be conclusive evidence. Any seemingly monarticular attack of rheumatism in children or young adults should always cause a consideration of acute osteomyelitis.

The pain and local symptoms, high leukocytosis, as well as the very sudden onset and absence of the Widal reaction, usually allow a distinction between typhoid and acute osteomyelitis to be made.

Any extreme pain in bone, with or without swelling, should always suggest the possibility of acute osteomyelitis. Both swelling and abscess formation may be delayed for several days. Acute suppuration occurring in a joint, as shown by aspiration of the joint, in the absence of general septicemia, should always lead the surgeon to trephine adjacent bones in order to eliminate a concealed bone focus.

In cases of localized abscess without sinuses or definite sequestrum formation recognition of the condition may be difficult. x-Ray photographs may demonstrate localized areas of softening in the bone surrounded by dense bone. In other cases the x-ray pictures are entirely inadequate to make a diagnosis. In cases of violent localized pain it may be necessary to cut down upon the bone and make a trephine opening before the presence of the localized abscess can be determined. Such cases must be distinguished from a local periostitis and from tumor, and distinction between these lesions frequently cannot be made except by operation.

Treatment.—Based on pathologic conditions, the course of osteomyelitis may be divided into four stages: *i. e.*, the stage of infection, necrosis, suppuration, and general intoxication; the subacute stage, which begins with the evacuation of the purulent exudate and the cessation of toxic absorption; the chronic stage, marked by the formation of sequestrum, involucrum, and sinuses; and fourth, the chronic stage of localized bone abscess.

Treatment of the Acute Stage.—In the acute stage there is suppuration of the marrow, more or less extended throughout the shaft, with often a subperiosteal abscess and perhaps abscess of the soft parts. The indications are the same as in any other acute suppuration, *i. e.*, the pus must be evacuated and the bone cavity must be drained. This demands not only an incision into the soft parts, but an opening into the shaft of the bone. For evacuation of the bone at first a good-sized trephine button, one-half inch in diameter, of cortical bone should be removed. If pus escapes from the marrow, this trephine hole should be enlarged by chisel and gouge, and should be extended along the shaft so long as definite pus escapes from the marrow. This may necessitate a removal of a lid of cortical bone for one or for several inches. One very important fact should be borne in mind: the marrow spaces everywhere communicate freely, although often indirectly, with each other, so that removal of a portion of the cortex alone is sufficient to drain the entire diameter of the bone.

It is extremely undesirable, however, as frequently is done, to remove with a curette all suppurating marrow. It is no more necessary to do that than it is to remove all the subcutaneous tissue of the forearm, *e. g.*, after the forearm has been incised for a phlegmon. The reason why it is undesirable is because curetting of the marrow brings about a destruction and removal of the endosteum of the marrow. As has already been said, the integrity of the internal surface of the cortex depends upon the integrity of the endosteum. Naturally, a portion of the endosteum ordinarily is destroyed by the suppurating process. Curetting of the suppurating marrow, however, removes whatever fragment of the endosteum has not been destroyed and practically leads to a necrosis of the inside of the cortex.

If the disease has extended to the epiphysis, it may be necessary to remove a portion of the cortex of the epiphysis. In some cases extension to and suppuration in the joint cavity may occur so early as to require opening and drainage of the joint at the primary operation, although usually the fluid in the joint in the very early days of the disease is due to edema and not to purulent infection.

In all cases interfere with the epiphyseal line as little as possible, especially in operating upon children, and particularly at the knee and more than all the epiphyseal line of the femur. In the lower extremity the growth of the bones in length is greatest at the knee and much less at the hip and ankle. In the upper extremity this is reversed—the greatest increase is at the shoulder and the wrist and least at the elbow. The entire body increases only 3.37 times from birth to adult life, but at the lower end of the femur the increase is 7.30 times.

In most cases by the time operation takes place the destruction of the marrow and of the endosteum is so extensive that a certain amount of necrosis of the inner layer of the cortex is sure to follow, and a sequestrum will ensue. In favorable cases operated on very early, so as to give drainage before destruction of the endosteum is extreme, a sufficient amount of endosteum will remain to regenerate the marrow, and the wound will heal by granulation. Complete regeneration of the bone will then take place with no formation of a sequestrum. Such a fortunate result, however, can be looked for only in exceptional cases.

Treatment of the Subacute Stage.—After the acute process has subsided, either from spontaneous or artificial evacuation of the pus, there comes the subacute stage, with necrotic shaft and proliferation of the periosteum. The amount and location of the necrotic bone may vary. At times only a longitudinal sliver of a portion or the entire thickness of the cortex may become necrotic. In such a case removal of the sliver may expose a layer of granulation tissue arising from the marrow. Such granulation tissue arises from the proliferating reticulum of the marrow and from the endosteum. Such tissue may grow up to the level of the removed cortex, periosteum may grow in from the sides, and ultimately the bony defect may in this way be replaced and complete healing be achieved. Such favorable cases are rare. More commonly there is a necrosis of the entire circumference of the shaft throughout its entire length or a considerable portion of its length. Such a necrosis must be entirely removed, or a permanent sequestrum inclosed by a shell of involucrum will persist indefinitely. The old surgical axiom was not to remove such sequestra until they were freely removable, which meant practically that they were not removed until after the involucrum was completely formed and ossified.

The treatment of such conditions may be divided into three classes: 1. Removal of the necrotic sequestrum before a definite involucrum has been formed, while the periosteum, although proliferating, is still plastic. 2. Removal of the sequestrum just as soon as a sufficient amount of involucrum has been formed to carry on the function of the original shaft. In the early stages such a young involucrum has a limited power of central growth, and in favorable cases may obliterate the cavity left by the removal of the sequestrum. 3. Removal of the sequestrum after the involucrum has become dense bone, like ordinary cortical bone. In such cases a cavity always is left surrounded by dense involucrum, lined with granulation tissue, and such a cavity will persist indefinitely because the dense involucrum has no power of central growth.

FIG. 13.—RESECTED AND REGENERATED LEFT TIBIA, SLIGHTLY IRREGULAR IN OUTLINE.
Skiagraph of bones of both legs, reduced about $\frac{3}{4}$.

1. *Removal of Sequestrum while Periosteum is Plastic.*—Early operation with plastic proliferation of the periosteum is chiefly applicable to those cases in which an accessory bone is present which may act as a splint and maintain the length of the limb during the process of bone regeneration; *e. g.*, the fibula may act as a splint-bone during the time of regeneration of the removal of a necrotic tibia. Such an operation is indicated in those cases in which there has been an extensive destruction of the entire diameter of the diaphysis over a greater or less length. If such a necrotic shaft is not removed, it will persist as a sequestrum indefinitely; periosteal involucrum will form, and if the sequestrum is removed late, the involucrum will not fill up the central cavity.

The time for this operation is when the periosteum has begun well-marked ossification in its deeper layers, and yet ossification is not so far advanced as to form a rigid periosteal shell. The time varies somewhat in different cases, but the average time is about the eighth week after the acute infection has been stopped by evacuation of the pus. The presence of well-marked ossification can be accurately determined by removal and examination of small bits of the periosteum from the edge of the sinus. The layer of bone formation should be about $\frac{1}{16}$ inch in thickness, although the thickness varies in different parts of the periosteum. In a rough way the presence of this bony layer can be determined by thrusting a needle through the periosteum at the edge of the sinus; if new periosteal bone has been formed, the needle passes through soft tissue, then through a crackling, thin layer of bone, and brings up against the dense shell of the necrotic shaft. At this stage *x*-ray photographs may show some decided thickening of the necrotic original cortex, but, as a rule, *x*-ray examination is much less satisfactory than microscopic examination.

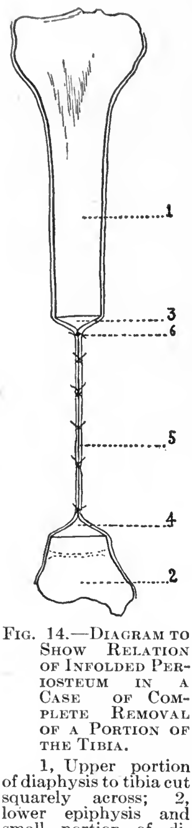


FIG. 14.—DIAGRAM TO SHOW RELATION OF INFOLDED PERIOSTEUM IN A CASE OF COMPLETE REMOVAL OF A PORTION OF THE TIBIA.

1, Upper portion of diaphysis to tibia cut squarely across; 2, lower epiphysis and small portion of diaphysis; 3, dead space between lower end of upper diaphysis and infolded periosteum; 4, dead space. 5, unfolded and approximated periosteum; 6, sutures.

The extent of the operation depends upon the amount of shaft which has been destroyed. In severe cases practically the entire diaphysis is destroyed. In such a case, removal of the entire diaphysis between the two epiphyseal lines may be indicated. In other cases only one-third or one-half of the shaft may be necrotic, while the rest of the shaft is viable and does not need to be removed. The amount to be removed can be determined by the condition of the periosteum, the amount of granulation tissue, and by the condition of the marrow.

It may be taken as a working rule that such portions of the shaft as show no endosteal thickening or ossification nor suppuration of periosteum probably will live. If at a given level the marrow shows no suppuration and only moderate injection, the limits of necessary resection are reached.

The most favorable time for removal being decided on, an incision should be made down to the necrotic bone. The periosteum is then stripped where necessary from the necrotic sequestrum, taking care not to perforate the periosteum. The necrotic shaft is then excised through normal bone. The periosteum is left behind as a broad, white ribbon. The edges of this periosteum should be brought together and fastened with catgut sutures, converting the ribbon into a flattened tube of periosteum. The soft tissue, after curetting and sterilization, is also approximated, and the leg put up in a sterile dressing and in a plaster. The periosteal tube continues to form bone until ultimately a new shaft of bone is formed, which becomes attached at either end to the remnant of unaffected bone.

The new shaft of periosteal bone at first grows until it is larger than the original shaft, probably because this newly formed bone is softer than normal, but in course of time, as the bone becomes harder, the excess of bone disappears, and a marrow shaft is created in the middle of the bone, so that ultimately the removed sequestrum is replaced by newly regenerated bone, which has exactly the same structure and is capable of the same function as the original bone. The first evidence of bony regeneration is felt usually at the end of three weeks, and the shaft is strong enough to allow use in from five to eight months. As far as function and use go, the results are usually absolutely perfect, and even in cases where the epiphysis is interfered with, the shortening may be slight and the function perfect.

2. *Removal of Sequestrum when no Accessory Splint Bone is Present.*—The above operation is particularly applicable to the bones like the tibia and fibula. In cases where there is only one bone in a limb, *e. g.*, the humerus, the danger of deformity from muscular contracture must be considerable if the necrotic shaft is removed before the periosteum is rigid. But, as has already been said, if the periosteal shell is allowed to become rigid, it has very little or no power of repair centrally, but in the early stages of the soft, rigid, periosteal shell, the periosteal shell or involucrum does have a certain amount of power of central growth. The difficulty of telling when this time has arrived is considerable, and can best be judged by means of the *x*-ray. It may be said, in a rough way, that the operation can be undertaken when the total diameter of the involucrum is equal to one-half the diameter of the normal shaft, *i. e.*, the operation must be undertaken at a somewhat later date than the operation in cases where an accessory splint bone is present. The time is approximately twelve weeks after the acute infection. At this time the shaft is necrotic; the involucrum is soft and vascular. In such cases an incision should be made down through the involucrum to the necrotic shaft. The necrotic shaft may be removed in its entirety or piecemeal, leaving a cavity surrounded by young involucrum. In favorable cases the involucrum will form new bone, which ultimately fills up the cavity and replaces the defect produced by removal of the sequestrum.

The operation requires almost as much time for complete regeneration, however, as the periosteal operation does, is much more likely to fail, and, on the whole, should be applied only to selected cases.

3. *Treatment of the Chronic Stage with Dense Involucrum and Extensive Sequestrum.*—At this stage there usually is an old necrotic shaft perforated by sinuses, and often freely movable, inclosed by a shell of dense periosteal bone. Like the cortex of normal bone, moreover, the ends of the sequestrum often are separated by a plug of very dense bone which has arisen from the endosteum and has completely occluded the marrow canal. This endosteal plug often is composed of dense bone like cortical bone, so that the sequestrum lies in a complete box of dense bone, which has no power of central growth. Removal of the sequestrum may give drainage, but the bony defect fails to heal, and persists as a filthy discharging cavity for months or for many years, with the con-

stant danger of secondary infection and phlegmon or erysipelatous inflammation.

Various methods have been used to close such bony defects. Such a cavity has been filled with pieces of sponge with the hope of having the sponge serve as a basis for the growth of granulation tissue, which should fill the defect and organize about the foreign body. This method has properly been given up.

Another method has been to sterilize as far as possible such a cavity and then fill it with blood-clot, close the skin over the clot, and trust to organization of the clot. In a very limited number of cases such a method is useful. It rarely succeeds, however, for obvious reasons. In the first place, the difficulty of sterilizing such a cavity which has been infected for many years is extreme, and organization of extensive blood-clots seldom is successful under any conditions, much less so in the presence of infection. When such a method is to be tried, there is one very important step in the operation. Bearing in mind that such cavities are surrounded with dense bone lined with very ineffective granulation tissue, it is necessary to provide some means by which a more satisfactory blood supply can be obtained, so that in such cases it is necessary to cut along the shaft of the bone through the dense plug across the marrow canal at either end of the cavity until vascular marrow is reached. Under these conditions, if the cavity has been rendered aseptic, it is possible in a limited number of favorable cases to obtain a sufficient blood supply from the marrow to enable the granulation tissue to organize an extensive clot. Many more of these cases will fail than the number which will succeed, even in the best of hands.

In other cases, following out Neuber's method, it is possible to obliterate the cavity without producing any new regeneration of bone. That is brought about by removing a portion of the cortical shell surrounding the cavity until the surface of the bone is more or less flattened and then inverting skin flaps from either side of the cavity which are fastened to these bony surfaces. In favorable cases such skin flaps will adhere to the bone, and in that way the granulating cavity is obliterated, although no marked increase in the size of the bone may be expected. Such an operation will, however, save the patient from the continual discomfort and dangers of the open, filthy, granulating cavity. In selected cases of this type the periosteal operation can be employed by removing sequestrum and involucrum, and using the remaining periosteum to regenerate new bone.

4. *Chronic Localized Abscess of Bone.*—Such an abscess may be small and circumscribed, or may occupy the greater portion of the shaft of one of the long bones. No definite sequestrum, as a rule, is present. Such abscesses always are surrounded by dense bone. After drainage of such an abscess by a trephine button a cavity is left with dense bony walls. The difficulties of closing such cavities are very great, for the reason that this dense wall has very little power of central growth, and such a cavity may persist with discharging sinuses for many years. Such a cavity under favorable circumstances may be filled up with blood-clot,

the surface of the wound being closed, and by organization of the clot the cavity may be obliterated. The same precaution must, however, be taken here as in the case of the blood-clot after the removal of sequestra; *i. e.*, pains must be taken to cut through the dense shell until vascular marrow is reached. In favorable cases organization of the clot may be expected; in other cases Neuber's skin-flap method is useful.

Mosetig's "Plumbierung."—Another method that is used for the closure of bone cavities was devised by Mosetig-Moorhof, of Vienna. He recommends that the cavities, after having been rendered perfectly aseptic and carefully dried, shall be filled with a mixture of iodoform, 60 parts, spermaceti, 40 parts, and oil of sesame, 40 parts. This mixture is heated until it becomes fluid, and is then poured into the bony cavity, which it completely fills and hermetically seals. The soft tissues are then sutured over this waxy plug, and he claims that in many cases the bone cavities completely heal with no further formation of sinuses. The iodoform plug sometimes is absorbed, and the cavity is filled up with organized bone. In other cases the plug is pushed out by the advancing granulations. In my own hands the results of this method of treatment have not been equal to claims made for it, but it is adapted to a strictly limited class of localized bone cavities. The filling of bone cavities by any foreign substance fails in many cases, just as do the attempts to fill such cavities by a blood-clot, which is to become organized, because it is almost impossible to render such cavities absolutely aseptic.

TUBERCULOSIS OF BONE.

Tuberculosis of bone always is dependent upon infection of the marrow of bone by the tubercle bacillus. The tubercle bacillus obtains access to the bone-marrow, and causes the formation of miliary tubercles which arise from proliferation of the connective tissue of the marrow around the primary tubercle. Other secondary tubercles are formed by extension of the tubercle bacillus. The centers of these tubercles become caseous, and by fusion of adjacent caseous areas an area of softening is produced in the bone-marrow. After the caseous process becomes more extensive, the bony trabeculæ involved in the caseous areas also become softened and dissolved, and may break down and form a definite cavity ("tuberculous abscess"), or a portion of the softened trabeculæ may persist as a definite "sequestrum," lying in a cavity surrounded by tuberculous tissue.

The tuberculous process, as a rule, begins in the epiphysis in the *long* bones. Very few cases, indeed, have been reported in which there was a definite demonstration of the occurrence of tuberculous disease of the shafts of the long bones. Since the process arises in the epiphysis and extends peripherally, the tendency of the tuberculous process in long bones is always to extend to and infect and involve adjacent joints (*cf.* pathology of tuberculous joints, page 283). The reaction and the clinical symptoms produced by destruction of the joints are perfectly characteristic, and are usually much more marked than the process in the bone itself. Consequently in tuberculous disease of the long bones the symptoms ordinarily are those of tuberculosis of the joints rather than tuberculosis of the bones.

The tuberculous process, however, may affect any of the bones of the body, and in some cases, notably in the ribs and in some of the flat bones, may affect bones at a long distance from any joint. In that case the pathologic changes are confined entirely to the bones or to adjacent soft tissues, and the symptoms are not complicated by the symptoms of in-

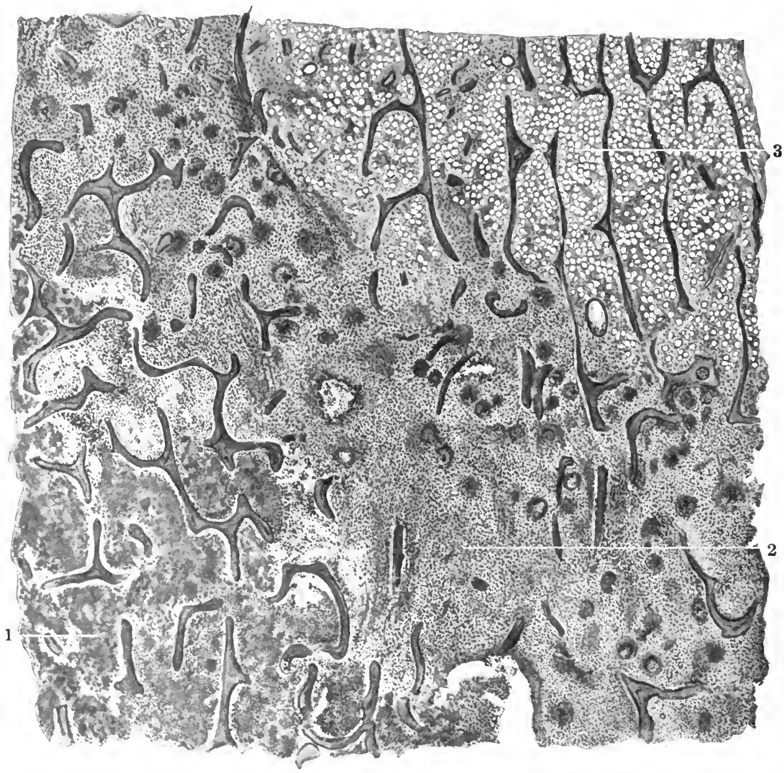


FIG. 15.—MICROPHOTOGRAPH THROUGH THE MARGIN OF A TUBERCULOUS BONE FOCUS. 1, Caseous bone-marrow; 2, zone of extending tubercles; 3, uninfected bone-marrow with excess of fibrous tissue, due to reaction about tuberculous focus.

fected joints. In such cases the clinical symptoms are quite different from those which are seen in tuberculous joints. As in the case of joint disease, the tuberculous process may extend through the cortex and periosteum of the affected bone by extension of the tubercles, and then by fusion of those tubercles areas of caseation may be produced in the adjacent soft tissues, thus forming a "cold abscess." Ultimately such a "cold abscess" may connect with the surface by various sinuses penetrating the skin at different points; or, in some cases, may extend inward and perforate into various internal hollow viscera.

Symptoms.—In cases of tuberculous disease confined to the bones alone, the first symptom usually is pain, which ordinarily is not severe and has a gradual onset. Oftentimes at first on palpation no difference in the shape of the bone can be detected. In one special instance, however, notable changes in the shape of the bone may occur early. This occurs when the phalanges of the fingers have been affected by the tuberculous process. This condition usually is seen in young children. Since the phalanges are small, the tuberculous process extends very rapidly, may involve the entire marrow of a phalanx, and destroy all the marrow. The process may then extend through the cortex and begin to affect the periosteum. In such cases an immediate reaction of the periosteum is produced, so that the tuberculous process is quickly surrounded by a new layer of the periosteal bone, very much like the involucrum seen about the necrotic shaft in cases of extensive osteomyelitis. The layers of new periosteal bone at first formed may also be attacked by the tuberculous process and cause a continued reaction of the periosteal layer. In such cases the phalanx of the finger rapidly enlarges, becomes more or less flask-shaped, with oftentimes a very thin cortex of newly formed periosteal bone. If this periosteal bone is incised, there appears a cavity filled with caseous material, and the remnant of a sequestrum of the original phalanx destroyed by the tuberculous process.

In young children both syphilis and osteomyelitis may also produce a similar appearance clinically, and the differential diagnosis between the two oftentimes is difficult or impossible except by the determination of the presence of tubercles or tubercle bacilli or of pyogenic organisms.

The fingers affected by this tuberculous process slowly enlarge, at first without heat or pain; ultimately the skin becomes thickened, reddened, and the digit is painful to pressure or motion. Oftentimes the skin is perforated at one or more points by sinuses lined with tuberculous granulations, through which caseous pus is discharged.

Tuberculous infection of the ribs and of the sternum also is common. In such cases the first symptom often is localized pain or tenderness, usually not severe. In the course of time the soft tissues surrounding such a bone become infected and adherent to the bone, or a cold abscess may form, which may perforate the skin through tuberculous sinuses. The diagnosis always in these cases lies between tuberculosis, actinomycosis, syphilis, and osteomyelitis, and exact determination of the origin of the cause oftentimes can be made only by inoculating animals with a discharge from the sinus, or by detection of pyogenic organisms or of the miliary tubercle, the histologic unit of tuberculosis, or by detecting the peculiar yellow bodies seen in actinomycosis. For symptoms of tubercular epiphysitis see Diseases of Joints.

Treatment.—From a clinical point of view tuberculosis of bone should be considered in the same category as malignant disease, and the indications of treatment in all cases of tuberculous bone disease are the same as in malignant disease, *i. e.*, complete removal of the infected area. This is true from a theoretic standpoint. From a practical point of view such treatment, however, is not always possible. Moreover, tuberculosis in children is largely a self-limited disease, and the mere opening and curetting of tuberculous areas in bone oftentimes is enough to set up sufficient reaction in the bone and in the surrounding tissues to put an end to the tuberculous process. In this way oftentimes may be avoided the complete resection of bones affected with tuberculous disease. In addition to the local treatment of opening, curetting, and drainage, or the complete excision of the bone, should be added the greatest care in the management of the general hygiene of the patient, including feeding and fresh air. Often removal to a climate which is unfavorable to the development of tuberculosis in general is also extremely desirable.

It is often better to avoid excision of bones, especially those which would lead to great impairment of function by the destruction of adjacent joints.

In adults, tuberculous disease of the bones offers a much worse prognosis than in children, and in adults extensive disease is often best treated by amputation rather than by any palliative measures, such as usually are acceptable in the case of children.

SYPHILIS OF BONE.

The lesions produced in bones by syphilitic infection may be congen-

FIG. 16.—CONGENITAL SYPHILIS.
Microphotograph of a portion of the epiphyseal line of femur. Shows persistence of cartilage and toothed epiphyseal line.

ital or acquired, and, as in other syphilitic lesions, the manifestations may be protean.

Pathology.—Most children with congenital syphilis show an irregularity of the epiphyseal line, which results in the epiphyseal line becoming toothed instead of being a straight line across the bone at right angles to the long axis of the shaft. This irregularity is due to abnormal transformation of the cartilage into the bone, as a result of which not all of the cartilage is changed into bone at the same time, but irregular lines of cartilage extend into the diaphysis. At times areas of softening appear along this irregular line, leading to spontaneous separation of the epiphysis, but this occurrence is rare. Besides this irregularity of the epiphyseal line, three other changes are seen in the bones as the result of syphilitic infection. The most common lesion is one which affects the periosteum and leads to the new formation of periosteal bone. This periosteal formation may occur either in congenital or acquired syphilis. It may affect one or many bones. In some cases it affects the shaft; in others, the epiphysis. The peculiar affection of the epiphysis was first called to my attention by Dr. Abner Post, of Boston. In some of these cases there comes an enormous thickening of the epiphysis of the bones, and, as a result of the epiphyseal thickening, secondary changes occur in the joints, so that the thickening of bones and the changes in the facets of the joints suggest fracture or dislocation (Fig. 17).

Fig. 17.—Syphilis of Long Bones (Post).
General enlargement of shafts of tibiæ, with marked enlargement of lower epiphysis of right tibia and resulting partial dislocation of ankle-joint.

In other cases the thickening affects only the shafts of the long bones, generally of the leg or the arm, although no bones are exempt. In other cases also, both in the congenital and acquired cases, there may be marked proliferation of the endosteum of the bone, with or without thickening of the periosteum, although thickening of the periosteum usually is present. This process, as a rule, affects one bone in its entirety, and most commonly affects the bones of the lower leg, notably the tibia. As a result of these changes the bones are enlarged and thickened, and in some cases from endosteal thickening the marrow canal is very largely or entirely obliterated.

In some cases true gummata of the bone are formed. These gummata may appear in the spongy portion of the bone—sometimes in the shaft or in the epiphysis. When they occur in the spongy bone of an epiphysis, especially if they occur near one of the large joints, secondary changes in those joints are likely to occur, and may produce a condition which clinically sometimes cannot be distinguished from tuberculosis of the joint or chronic arthritis.

In other cases the gummata appear to be formed in the lower layers of the periosteum, and lead to circumscribed nodular thickenings on the surface of the bone. In some cases, especially over the sternum, the collar-bone, and notably the skull, extensive gummatous process may cause a very extensive solution and necrosis of the bones, with formation of large cavities or perforations, and sometimes large necrotic sequestra.

Fig. 18.—Skiagraph of Congenital Syphilis of Left Humerus.

Showing diffuse thickening of periosteum. At one place is a suggestion of gummatous softening.

In children gummata may affect the marrow of the phalanges. In such cases, since the phalanges are small, the entire marrow may be destroyed and the trabeculæ become necrotic. This necrosis is followed by proliferation of the periosteum, which forms a new layer of cortical bone. As a result of this periosteal activity the shaft of the phalanx increases in size and assumes a peculiar flask shape, similar to that seen in tuberculosis and osteomyelitis. The gummatous softening may extend to the soft tissues and open on the surface.

Symptoms.—The symptoms vary with the different pathologic conditions present. The change in the epiphyseal line in congenital syphilis usually is unrecognized except at autopsy. In a very limited number of cases, however, in children shortly after birth, there may occur a spontaneous separation of the epiphysis. The diagnosis can be made only by the history and by the detection of other symptoms of congenital syphilis.

The periosteal thickening may occur at any time of life over any bone of the body. The presence of circumscribed periosteal thickening of bone in itself should always lead to the suspicion of the presence of syphilis. The diagnosis, of course, depends upon the history and the detection of other syphilitic lesions and upon the results of treatment. Most of these cases have pain, which, however, is of only a moderate degree of severity.

The cases in which there is both endosteal and periosteal thickening have, in my experience, occurred chiefly in children, and have been mostly in congenital syphilis. The symptoms there are quite characteristic. Cases of such lesions do, however, occur in adults. The bone affected usually is the tibia, which is enlarged to a most marked degree, and often shows a pronounced bowing forward, similar to the bowing and thickening of the tibia seen in osteitis deformans. The bone is extremely dense and obviously heavier than normal. The bones often are moderately tender to pressure, but have nothing like the extreme tenderness seen to pressure on osteomyelitic bones.

In cases of gummata of bones the symptoms vary. In some cases

FIG. 19.—CHRONIC SYPHILITIC DACTYLITIS.

the gumma is in the center of the spongy portion of one of the large long bones, and in such cases no clinical symptoms whatever may appear, and the cases may be recognized only at autopsy. In other cases, *e. g.*, with disease of the lower end of the femur, secondary changes in the knee-joint may appear. These joint changes, on the whole, are of the same type as those seen in chronic arthritis, and the detection of the fact that they were caused by syphilis would depend entirely upon the recognition of a general syphilitic condition.

In other cases the gummata are on the surface of the bone, especially the sternum, the collar-bones, occasionally the ribs, and rarely the long bones. In such cases there appear a softening and reddening of the skin about the affected area, which remains indolent for a long while. If such an area opens spontaneously or is opened by incision, the contents are seen to be composed of a yellow, rather gelatinous material, quite unlike the caseous material from a tuberculous abscess. Occasionally such areas affect the skull and rarely extend over very considerable areas, and may cause perforation of the skull, or the formation of enormous sequestra, and may lead to destruction of a large part of the cranial vault.

The diagnosis in cases of gummata of bone lies between tuberculosis, actinomycosis, and localized osteomyelitic abscess.

Actinomycosis may be recognized by the presence of the characteristic granules; tuberculosis, by the recognition of the histologic tubercle or by the inoculation of animals; osteomyelitis, by the presence of pyogenic bacteria; syphilis, of course, by the history and the presence of other syphilitic lesions.

Treatment.—Treatment in most cases is the regular anti-syphilitic treatment. The results, however, vary with the condition. In syphilitic disease of the epiphyseal line usually no symptoms appear which would call for special treatment. The condition more or less disappears as the syphilis improves. In the cases of periosteal thickening the results vary with the time at which treatment is begun. In the early cases, during the formative period, a thorough anti-syphilitic treatment may lead, after a varying length of time, to complete disappearance of the newly formed periosteal bone. On the other hand, if the periosteal process has lasted for a long time and the bone has become dense cortical bone, although anti-syphilitic treatment may lead to a diminution of the localized pain, the dense bone does not disappear.

In the cases of combined endosteal and periosteal thickening the pain usually disappears under anti-syphilitic treatment, but the changes in the bone persist.

In cases of gummata of bone on the surface, the gummata may entirely disappear under treatment.

The syphilitic dactylitis under treatment becomes quiescent, sinuses heal, and redness and tenderness disappear. In many cases, however, the finger remains short and misshapen.

RICKETS.

As has been stated in vol. i, page 580, rickets is an acquired disease of children, due directly to faulty feeding, although the manner in which this faulty feeding acts to produce the general deformity of the bones is not known.

The changes in rickets are brought about by an irregularity of ossification, chiefly in the long bones, the changes being confined largely to the epiphyseal line at the junction of epiphysis and diaphysis. As a result of these abnormalities deformities of all the bones of the body are brought about, resulting in changes in the shape of the head, in enlargement and shortening and bending of the long and other bones, with certain secondary symptoms in the lungs and in the nervous system.

There has been much discussion as to whether rickets is ever a congenital disease. The subject at present must be considered to be *sub judice,* with a very great probability that true rickets never does occur as a congenital disease. Numerous cases of so-called fetal rickets, however, have been reported. Most of these cases, however, are ones with an entirely different pathology and origin, and usually are cases either of

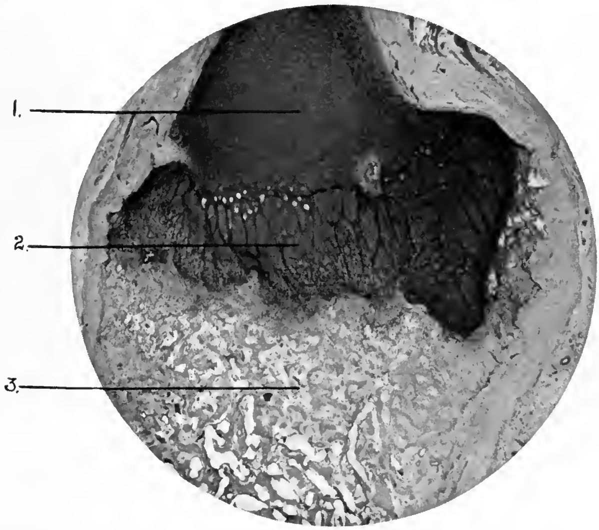


Fig. 20.—Microphotograph of Epiphyseal Line in Rickets.
1, Hyaline cartilage; 2, hypertrophic cartilage; 3, marrow canal with trabeculæ and marrow spaces.

chondrodystrophia fœtalis or of osteogenesis imperfecta. (See also Vol. I, p. 578.)

OSTEOGENESIS IMPERFECTA.

This is a congenital disease characterized by fragility of the bones, with resulting fractures, frequently multiple, and is due to a lack of formative power in the bony tissues. The cause of this lack of power is not at present known. There have been about 130 cases of this sort reported in medical literature.

Etiology.—The true cause of the process is absolutely unknown, although in a very considerable proportion of the cases a certain element of heredity is present. It is said that about 15 per cent. of the cases show a hereditary history. The disease is congenital, but the time at which the fractures appear varies from intra-uterine life up to two or three years. The number of fractures is very variable, from two to one hundred or more being reported. Many of the cases occur in still-born children, but some of the cases have lived.

Pathology.—The chief change is in the bones. The series of changes which occur at the epiphyseal line and in the bone-depositing layer of the periosteum both are abnormal. The epiphysis is composed of normal hyaline cartilage. The marked change comes at the epiphyseal line, where, in contradistinction to normal ossification, the cartilage cells persist, their capsules do not rupture, and masses of such cells extend into the shaft of the bone. (In normal ossification the matrix between the cartilage cells only persists.) On these new trabeculæ few osteoblasts are seen, but the capsules of the cartilage cells themselves thicken and lime salts are deposited in these capsules. By coalescence of adjacent capsules a solid bony mass is formed, *i. e.*, the newly formed trabeculæ are formed by calcification of cartilage cells and not by new bone formation by osteoblasts upon a persistent cartilaginous matrix.

Fig. 21.—Microphotograph of Epiphyseal Line in Osteogenesis Imperfecta.

The further development of these metaplastic trabeculæ is abnormal. In normal bone the trabeculæ become laminated and the bone-cells become stellate. In this disease the bone-cells always remain large, oval in shape, and are much more numerous than normal. The trabeculæ also show no or imperfect lamination. The periosteum also does not form normal bone. The fibrous layer of the periosteum is thicker than usual. The deeper layer of the bone-forming cells (the periosteal osteoblasts) also is thick, but the cells are more spindle-shaped than usual. New cortical bone is formed by these cells. Under normal conditions the cortex consists of a continuous layer of laminated dense bone in which are stellate bone-

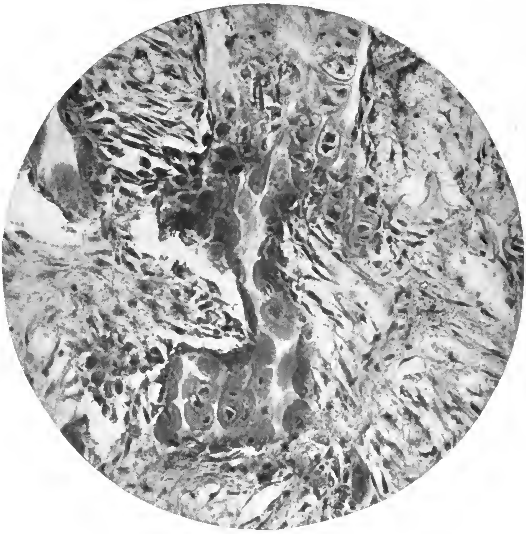


Fig. 22.—High-power Microphotograph of Ossifying Cartilage Cells of Epiphyseal Line of Osteogenesis Imperfecta.

Cartilage cells surrounded by zone of calcification uniting to form new trabeculæ.

cells and Haversian canals. In this disease the periosteum forms separate plates of non-laminated or imperfectly laminated dense bone in which are oval bone-cells and no Haversian canals. Instead of Haversian canals, are large marrow spaces. The trabeculæ in the marrow canal are much less numerous than normal.

The marrow spaces of epiphyseal and of periosteal origin are filled with abnormal marrow. Near the epiphyseal line the marrow is almost entirely edematous myxomatous connective tissue. Further away from the epiphysis the center of the marrow spaces is filled with normal marrow, surrounded and separated from the trabeculæ by a zone of connective tissue. The trabeculæ everywhere are studded with flattened osteoblasts, but there is no evidence of osteoid tissue. Giant-cell absorption is slight. The process of bone formation everywhere is checked and of an abnormal kind.

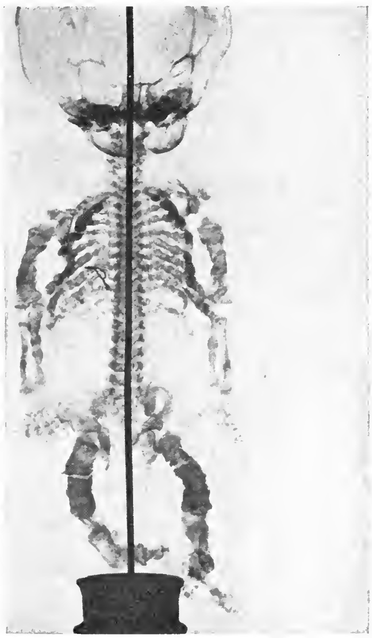


FIG. 23.—SKELETON OF A CASE OF OSTEOGENESIS IMPERFECTA (Warren Museum, Harvard Medical School). Showing very numerous fractures.

As a whole, metaplasia of cartilage is much greater than normal, while deposition of bone is much less. Formation of periosteal bone is abnormal and incomplete.

Symptoms.—The children, as a rule, are smaller than the average, and in most cases the lower limbs have been abnormally short in relation to the trunk. The children usually are well nourished. In many cases the skin is thick and edematous, and a cretinoid type of face is seen. The skull sometimes is so imperfectly ossified as to represent nothing more than a fluctuating bag of membrane. Fractures may occur *in utero* and show deformities due to healing of those fractures at birth, or fractures may occur during delivery, or after birth under the slightest possible pressure or motion. The fractures, as a rule, heal readily, sometimes with, but oftentimes without, marked formation of an external callus. Many of the cases have been still-born, and but few have lived for many months. Many show other deformities, such as club-foot and rachischisis.

Treatment.—For the fractures occurring *in utero* of course nothing can be done, nor is there any means of making the diagnosis before birth. A fracture occurring during delivery without apparently adequate physical cause should lead to a suspicion of the presence of this condition, and should cause the accoucheur to take especial pains to avoid unnecessary force. For the fractures which occur after birth ordinary treatment can be carried out, bearing in mind that it is necessary to avoid, however, any special pressure upon unbroken bones for the purpose of immobilizing those already broken. In all cases it is desirable to avoid manipulation of the children as far as possible either by having them recline upon a Bradford frame or a hard pillow. Manipulation of the limbs should be avoided as far as possible by dressing the child in garments which need no unnecessary movements of the body when changing. In many cases, however, in spite of the most extreme precautions, repeated fractures will occur from mere muscular contraction.

As far as medical treatment is concerned, in the absence of the knowledge of etiology there is no special therapeutic indication. Most of the children die young. The only thing that can be done is to look after, as far as possible, general nutrition and hygiene.

CHONDRODYSTROPHIA FŒTALIS—ACHONDROPLASIA.

This is a rare congenital disease, the children suffering from which frequently are still-born, or survive birth but a short time. The disease was not recognized as a definite disease until 1860, when Müller differentiated it from cretinism and rickets, and showed that the failure of the long bones to develop was due to disturbance of the zone of proliferating cartilage at the epiphyseal line.

Fig. 24.—Skeleton of a Case of Chondrodystrophis Fœtalis (Warren Museum of the Harvard Medical School).

The disease, together with osteogenesis imperfecta, formerly was confused with rickets, and most of the cases of the so-called "fetal rickets" are really examples of one or the other of these two conditions.

The gross bony changes in chondrodystrophia in many respects simulate the changes seen in acquired rickets; hence confusion of the two has been easy. Children suffering with chondrodystrophia have a characteristic appearance. They are dwarfed; the bridge of the nose is retracted; the limbs are short and curved. The abdomen always is prominent; the legs are relatively very short, as also are the arms. The long bones, besides being short, are usually much curved. The hair is of normal thickness; the skin is thin, but well nourished; the hands and feet both are short and rather spade-shaped, all the fingers being of about the same length, giving a curious deformity of the hand, which has been described by Marie as the "main-en-trident." The shortening of the limbs is marked when the child is born, but as growth takes place the curves of the bone become more exaggerated, and the bones thicken in diameter. The epiphyses also are much enlarged and simulate more or less the rosary of rickets.

The skull bones, however, as a rule, show no marked deformity, and in that respect differ very markedly from the skull of rickets; the arch of the skull usually is high.

The mental condition is un-

Fig. 25.—Chondrodystrophia Fœtalis (Children's Hospital, Boston).

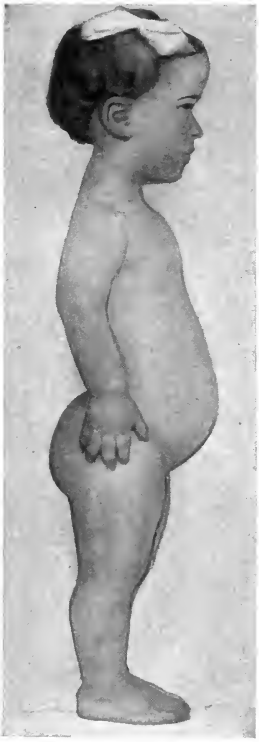


Fig. 26.—Chondrodystrophia Fœtalis (Children's Hospital, Boston). Note the peculiar malformation of the hands—"main-en-trident."

changed, and the only case which has come under my own observation was a child who was remarkably intelligent for his years.

The mobility of the joints sometimes is most extraordinary, it being possible to move the phalanges one upon another just as though they were fastened by ball-and-socket joints. It is said that these children are particularly likely to have other congenital deformities, such as a high palate, hernia, or congenital dislocation of the hip.

Etiology.—As to etiology of the disease, nothing whatever definite is known.

Treatment.—In the line of surgical treatment nothing can be done. The disease is one of development, the origin of which is absolutely unknown. The resultant deformities frequently are extreme.

FRAGILITAS OSSIUM.

Abnormal fragility of the bones is a not infrequent occurrence. The term "fragilitas ossium" (osteopsathyrosis), however, does not specify a definite disease, but rather expresses a clinical condition. This is so because many causes may lead to the symptoms of fragility and fracture of bones. The term describes fragility due to any cause and occurring at any age, and has been divided into two classes—(1) the "symptomatic fragility," where the change is due to any one of various pathologic conditions, and (2) "idiopathic fragility," which is a congenital condition identical with osteogenesis imperfecta.

FIG. 27.—"FRAGILITAS OSSIUM" (Warren Museum, Harvard Medical School).

Skeleton of an adult Indian. Probably adult osteogenesis imperfecta.

Symptomatic fragility of bones may be brought about by a great variety of conditions. It may be due to the special conditions due to lacunar resorption, which occurs sometimes secondary to the softening of bones produced by rickets. It also may occur in old people on account of advanced lacunar resorption, which often appears with advanced age. It may also occur in some of the inflammatory affections due to bacterial infection where there has been marked destruction of certain portions of the bone, *e. g.*, in osteomyelitis or tuberculosis.

Fragility of the bones also occurs occasionally in connection with definite lesions of the central nervous system, such as tabes, syringomyelia, or paralysis. It also occurs secondary to the presence of certain malignant tumors, such as sarcoma or carcinoma in bone, or from the presence of cysts, due either to degeneration of tumors or to the presence of echinococcus.

In many cases it is extremely difficult to make a definite diagnosis as to the cause of the recurrent repeated fractures. All the above causes mentioned must be borne in mind, and the diagnosis made by a method of elimination so far as possible. For this purpose the *x*-ray has proved a most valuable method of investigation.

LEONTIASIS OSSIUM.

Occasionally the bones of the skull are affected by new-growths of bone. These new-growths, or hyperostoses, may be general or localized, *i. e.*, may be diffuse or tumor-like.

The diffuse hyperostoses frequently cause enormous enlargement of the skull (Surgery of Jaws, Vol. III). The new bone extends over all of the face bones and the bony vault. The sutures disappear, and the surface is rough and irregular. The new-growth of bone may extend in such a way as to obliterate more or less the openings for the exit of the cerebral nerves. The orbits frequently are entirely filled and may be obliterated. The structure of the bone usually is very dense and eburnated. Relatively little is known of the histologic changes.

Symptoms.—The deformity of the skull is the chief clinical change. The deformity frequently produces a characteristic change in the contour of the face, giving it a heavy, "lion-like" appearance—hence the name. The eyes usually are extremely prominent. The chief subjective symptom is the occurrence of headache, which sometimes is constant, in other cases comes in recurrent paroxysms. Secondary symptoms of various sorts may arise, due to pressure upon the cerebral nerves at their point of exit from the skull by the bony growth. The disease generally begins late in childhood and progresses slowly. Young women are most frequently affected. In the absence of knowledge of the cause, treatment, when the disease is diffused, can be only symptomatic. When it is local, removal of the exuberant bony tissue by chiselling is advisable, both for cosmetic reasons and for cure. When thus removed, it does not recur.

Localized hyperostoses in some cases appear upon the skull, giving rise to flat or nodular growths of various size and shape. In some cases these hyperostoses grow into the skull and cause compression of the brain, often without cerebral symptoms; such cases are rare.

OSTEOMALACIA.

Osteomalacia is an acquired disease which causes marked softening of the bones and changes in the bones similar in many respects to the changes seen in rickets. Osteomalacia, however, is a disease of adult life. It is found widely distributed, but is much more common in Europe than it is in the United States. It is a disease seen most commonly among the poor, although it may occur among the well-to-do and well nourished. In the vast majority of cases the disease occurs in women, especially in women who have had frequent consecutive pregnancies. There is no evidence that inheritance has anything to do with the disease, although the children of women with osteomalacia frequently show signs of rickets.

Etiology.—The worst cases are seen in women after frequent consecutive pregnancies; exposure to cold and wet and bad nutrition are also predisposing causes. The actual cause is at present not determined. An absence of lime from the food probably has nothing to do with the occurrence of the disease (*cf.* Rickets, Vol. I). It is likely that the disease may be the result of some complicated organic secretion—perhaps some unknown secretion from the genital organs.

Pathology.—The bones are fragile, soft, and deformed. The cortex is thin, and in extreme cases may be only a thin shell of thickened periosteum; they are easily cut. The periosteum itself usually is normal or somewhat thickened, and the external surface of the bone is rough and uneven.

In the long bones there is marked absorption of the trabeculæ with a marked new formation of a limeless material about the trabeculæ closely resembling osteoid tissue, with perhaps an inner center of lime-bearing trabeculæ. In the short bones the trabeculæ may entirely disappear, and the marrow spaces become enormously enlarged, or the trabeculæ may be composed of tissue like the osteoid tissue.

Under the microscope the trabeculæ are seen to be composed largely of a bony center, surrounded by material having the structure of bone, in which no lime salts have been deposited. The question is whether this limeless material is the result of a decalcification of bone which at one time did contain lime salts, or whether it is a new formation of osteoid tissue in which no deposition of lime ever has taken place. The question is very much disputed, and cannot be said to be entirely settled, but the probability is that the process is one of decalcification, because in certain cases the softening of the bone is so rapid as to make it improbable that the process is one of new formation. Chemical analysis shows that relatively and actually there is a loss of lime combined with an increase of the organic substances in the bone.

In puerperal osteomalacia the first change generally occurs in the pelvis, then in the spine, thorax, shoulder-girdle, and limbs. The skull is usually normal. The softening of the bones leads to increased pliability of the bones, and results in various bendings under pressure, and in certain cases to fracture of the bones. The vertebræ become flattened, especially in the lumbar region, and the spine also may show various lateral and rotary curves. The pelvis at first is like the flat pelvis of rickets; later, however, the promontory sinks, the iliac bones approach each other, and the symphysis becomes more prominent, resulting in the so-called "heart-shaped" pelvis. The changes are, however, frequently asymmetric. The sacrum frequently becomes bent forward; the breast becomes prominent; the ribs may sink in laterally or may become fractured. The clavicles become bent as in rickets. The bones of the lower limb are almost always involved; sometimes the legs seem enlarged, at other times they are small and short. Knock-knee or, more rarely, bow-legs may occur. The skull is rarely involved. Secondarily the muscles may become weak, atrophied, or undergo fatty degeneration. The ovaries oftentimes atrophy, or there may be simple cysts of the ovary. The changes of the internal organs are all secondary to the bony changes.

Symptoms.—The disease begins irregularly and often progresses with or without remissions. The progress usually is more marked during pregnancies. In some cases the disease comes to a halt and complete recovery occurs. Other cases go on to a fatal result.

The first sign is apt to be pain in the bones, commonly at first of a dull character. Pregnant women often complain of pains in the pelvis, increased by motion or by holding the limbs long in one position. Later the pains may become localized in separate bones, and that pain may be increased by pressure, and this is especially true of pressure over the

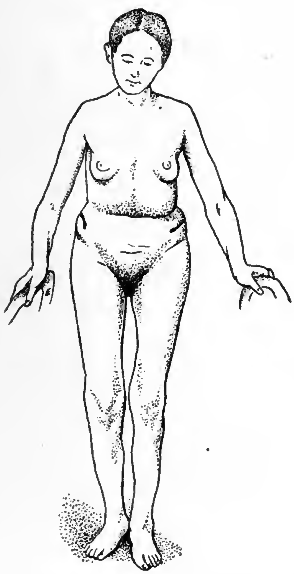


FIG. 28.—PUERPERAL OSTEOMALACIA (after v. Winckel).
Shows characteristic gait, with support for hands.

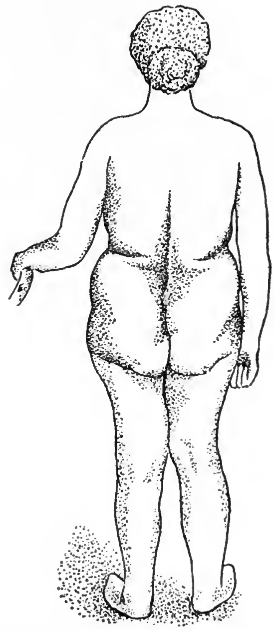


FIG. 29.—OSTEOMALACIA (after v. Winckel).
Shows transverse fold.

ribs. In certain cases there are muscular cramps and contractures. The pain frequently is worse during menstruation.

The patient assumes frequently a characteristic position, being bent forward, walking with short steps, and a curious gait resembling the gait of spastic paralysis, and depending upon lateral support by the hands. There is frequently a lumbar furrow, seen most clearly in the back, below the ribs, due to the sinking down of the spine, and this furrow may extend forward below the edge of the ribs. The pubic bones are prominent, and the trochanters are nearer together than normal.

The appetite and bodily functions usually are normal. In extreme cases the deformities may become extreme, with valgus position of feet and outward bowing of the thighs. In many cases complete or "greenstick" fractures occur. These fractures heal with the formation of a slight callus, or may persist with the formation of pseudo-arthroses.

Many of the people look old before their time. The general health is impaired in extreme cases, and after the patients are confined to their beds, they are especially liable to decubitus. Many of the cases cease to progress, or even recover, after the climacteric.

Treatment.—The results of treatment depend upon the stage at which treatment is begun. In the early cases good results can be expected. In the extreme cases very little can be done. Many of the cases live many years. General hygiene should be looked after, and cold and dampness should be avoided. In the case of women, they should be warned against frequent pregnancies. Medical baths are said to be useful in some cases. No drug is known to have any definite beneficial action. In the puerperal cases removal of the ovaries in some cases is said to have given brilliant results. The operation was done at first for the purpose of avoiding repeated pregnancies, and since then has been done as a direct medicinal measure. The value of the operation is, however, somewhat doubtful.

OSTEITIS DEFORMANS (PAGET'S DISEASE).

This is a chronic disease of the bones first described by Sir James Paget in 1877. It is a disease of the later years of life; may affect one or,

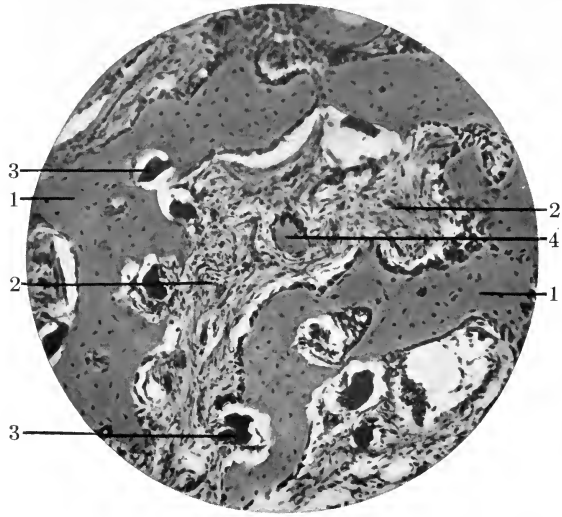


Fig. 30.—Microphotograph of Section of Tibia from a Case of Osteitis Deformans. 1, Trabeculæ; 2, fibrous marrow; 3, osteoclasts; 4, giant-cells in lacunæ (resorption of bone).

more often, several bones of the body, notably the bones of the lower limbs; is progressive and ultimately leads to very great deformity of the bones. The disease was formerly supposed to be extremely rare, but it is much more common than ordinarily has been supposed, Dr. E. E. Locke, of Boston, within a relatively short time having had twenty-five cases of the disease under observation.

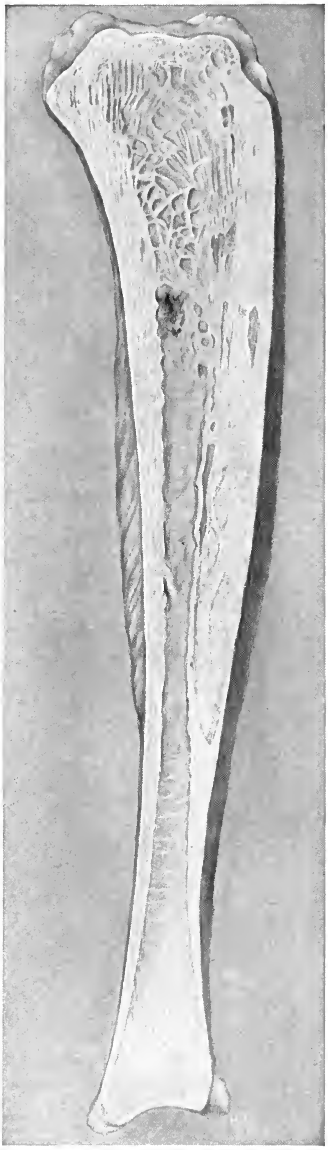


FIG. 31.—SECTION THROUGH TIBIA, SHOWING OSTEITIS DEFORMANS WITH SARCOMA OF POPLITEAL SPACE (Locke and Goldthwaite).

Etiology.—Paget considered the disease a "chronic inflammation" of the bones. Others have considered the disease to be due to some constitutional disturbance which caused atrophy of a portion of the bones and hypertrophy of other portions. Both syphilis and organic nervous disturbance also have been alleged to be causes of the disease. The actual etiology at present is unknown, but the changes in the bone are almost always associated with very marked arteriosclerosis, and this may be marked even in people relatively young.

In many cases the main arteries of such patients are completely calcified. Associated with these arteriosclerotic lesions also frequently are valvular lesions of the heart, which are due to arteriosclerosis, and not to preceding attacks of rheumatism. In many of the cases, too, tumors of various portions of the body also are common. Cases of osteitis deformans have been reported in association with endothelioma of the pleura, cancer of the liver, sarcoma of bone, etc. In one case which came under my observation there was a sarcoma of the lower end of the femur. Cases of gastric cancer in connection with this disease also have been reported. In about 20 per cent. of the cases a certain element of heredity appears. The sexes are affected about equally, although naturally the characteristic deformity is more readily noted in men than in women. The disease frequently appears relatively late in life, but Locke believes that the characteristic changes appear much earlier than is usually believed.

Pathology.—The changes in the bone are a combination of bone absorption and of bone hypertrophy, the combination leading to changes in the external shape and the internal structure of the bones. There also is, to a certain extent, a new formation of tissue like osteoid tissue.

The bones which are chiefly affected are those which are in the axis of the skeleton, namely, the skull, spine, long bones, especially of the lower extremities, with ultimately, to a less degree, changes in the face and fingers.

In the skull there is formed considerable new bone in the outer laminæ, arising probably from the periosteum. This new bone at first is soft, vascular, and porous, but later becomes dense and eburnated. There also may be new formations inside the skull. As a result of this periosteal thickening of the skull the head may become very much enlarged, although the enlargement is generally uniform. There also may be great enlargement of the bones of the face.

Fig. 32.—Osteitis Deformans.
Shows enlarged head, with slight frontal bosses, prominent clavicles, slight bending of arms, general outward bending of legs, and anterior bowing of tibiæ.

The changes in the spine are fairly characteristic; a marked kyphosis confined to the lower cervical and dorsal regions appears, without torsion or scoliosis. In certain cases the bodies of the vertebræ are wedge-shaped. The pelvis, as a rule, is but little affected, but ultimately may become heart shaped, as in cases of osteomalacia.

The long bones of the legs are chiefly and earliest affected. In most cases the changes are marked in the femur, tibia, and fibula. As a result of the bony changes these bones become bowed, while their internal trabecular structure is altered.

The extent of the affection in the bones of the legs varies a great deal, and usually is not symmetric. The lower extremities are bowed outward, the curve being due to changes in the shape of the femur and of the lower leg, and also usually are bent forward. In certain cases the clavicles also are much deformed.

Symptoms.—The disease is insidious in its origin, and before actual bony deformity occurs, long-continued indefinite pains in the legs may have existed with occasionally tender points over the bone. The bony changes usually are first noted in the bones of the leg, although in certain cases the symptom which first calls the attention of the patient to his disease is the fact that his head is slowly enlarging, shown by the fact that the size of his hat constantly must be increased. The pain in the legs, seldom severe, ultimately may entirely disappear, and, in fact, usually does so. The legs slowly become stiff and weak, and after bony changes occur, a very characteristic waddling gait appears. The peculiar bony changes have been mentioned.

Diagnosis.—In a well-marked case mere inspection of the attitude and of the gait suffices to make a diagnosis. The head is disproportionately large, and is held forward with the chin resting on the sternum. The back is bowed, the legs are bowed outward, and there is a marked curve of the tibiæ forward; the knees cannot be brought together; the feet are rotated outward; the shoulders are high; the arms seem disproportionately long, and are held somewhat curved, so that the entire attitude and gait more or less resembles that of some of the apes. The clavicles may be prominent, while the chest is small and rigid. The abdomen often is small but protruding. The gait is a characteristic waddle.

The differential diagnosis must be made between syphilis, osteomalacia, arthritis deformans, acromegaly, and diffuse hypertrophy of the skull.

Syphilis may cause an enlargement of one, rarely of several bones of the body, but it begins much earlier, as a rule, than the cases of osteitis deformans. Syphilitic treatment in early cases may cause a diminution in size of the enlarged bones of syphilis, but in the advanced cases, after the new-formed bones have become eburnated, specific treatment has no effect. The distribution of the lesions is much unlike that of osteitis deformans and seldom affects the skull.

Osteomalacia may present kyphosis of the extremities, deformities of the pelvis, and pain. The disease, however, is most marked in the lumbar spine, and the gait is entirely different. The bones are very fragile.

In arthritis deformans the lesions are confined to the joints. The kyphosis is due chiefly to the fixation of the spinal articulations, and not so much to the deformities of the bones, and there is no hypertrophy of the long bones.

In acromegaly there are a large skull, kyphosis, projection of the eyebrows, and thickening of the long bones, as in osteitis deformans, but there also are characteristic changes in the face and soft parts, and the lesions are symmetric.

In diffuse hypertrophy of the skull there may be enlargement of the bones of the skull, but there also occurs obliteration of the hollow places of the skull, usually with exophthalmos and frequently cerebral nerve-paralysis. It also is a disease which begins in young people and not in the old.

Fractures occasionally occur in the bones of patients affected with osteitis deformans. In the one case which has come under my observation, however, the repair of the fracture took place in the ordinary length of time, with only a small callus.

Treatment.—In the absence of any knowledge as to the cause of the disease, the treatment of osteitis deformans must be largely symptomatic. Certain drugs have been highly recommended. Iodid of potash has been recommended, apparently on the assumption, which is not justified, that the disease may be of syphilitic origin. Arsenic also is recommended in many cases. Most of the cases are in very poor general condition, and many have been on a so-called "anti-rheumatic" diet and are poorly nourished. In such cases effective feeding often gives marked relief of the symptoms from which the patients are suffering.

For severe pain counterirritants are valuable, notably counterirritation by the actual cautery. In some cases massage is of use for improvement of the general condition.

ACROMEGALY.

Acromegaly was first described as a definite pathologic entity by Marie in Charcot's clinic. It is an acquired disease, characterized by peculiar changes in the bony system dependent upon disease of the pituitary body. The disease is essentially a chronic one, often lasting for many years. The beginning is not noted, and only after marked bony changes have occurred is the attention of the patients or oftentimes of the patients' friends, called to the disease.

Fig. 33.—Acromegaly.
Shows prominent forehead and nose, undershot jaw, heavy expression.

Etiology. — Various causes have been assigned for the disease. There is, however, but one constant factor, *i. e.*, disease of the pituitary body. The character of the change in the pituitary body is very variable. It may be either hypertrophy with or without colloid degeneration, glioma, or sarcoma.

Pathology. — The bone lesions usually are symmetric; the bones are thickened and rough, oftentimes with small exostoses similar to the exostoses for the attachment of tendons. The skull is large, with rough muscular insertions. The lower jaw usually is enormously enlarged—so much so that the jaw is undershot. The changes in the ramus of the jaw may lead to falling of the teeth. The face is long and oval. The thickening of the bones ultimately may lead to pain from pressure of various cerebral nerves. The spine ultimately becomes more or less kyphotic, especially in the dorsal region and in the neck. Occasionally lateral curves develop. The bodies of the vertebræ frequently are compressed. The ribs are big and thick; the sternum wide and large; the rib cartilages calcified and thickened. The chest is large and flat laterally. The processes of the scapula show enlargement. The pelvis is massive. The enlargement of the long bones is less marked than that

Fig. 34.—Acromegaly.
Hand of same patient shown in Fig. 33.

of the bones of the trunk. The hands and feet, however, are usually extremely large.

The histologic changes are not well understood. The changes are very largely due to a new deposit of bone by thickened periosteum, while in the marrow there may be evidence of coincident lacunar resorption. The cortex may be thick or thin, while the marrow is vascular.

Symptoms.—The process may last for years. One of the most marked symptoms is the change in the size and shape of the head and the change in the shape of the face. The hands and feet are large; the face is coarse; the nose large; the lips thickened, especially the lower, and in some cases the tongue becomes so large that it is too big for the mouth. The eyebrows frequently are prominent, due to thickening of the bone underneath. The spine is bowed; the chest is prominent. The voice becomes coarse and rough. The patients frequently have enlargement of the heart and marked arteriosclerosis. Sexual changes are marked: in men potency is lost early, and in women a suspension of the menses occurs early. Many of the cases have diabetes and chronic indigestion. In some cases exophthalmos is marked. The skin may become thickened, and there may be marked pigmentary changes. Headaches sometimes are extreme, and there are frequently nervous

Fig. 35.—Skiagraph of Acromegaly.
Skiagraph of hand, showing density and thickening of bones.

symptoms. The course of the disease may last from two or three to fifty years.

Treatment.—The treatment is, in general, attention to general hygiene and treatment of symptoms. It is said that very satisfactory results have been obtained by treating the cases with thyroid extract.

TUMORS OF BONE.

All the primary tumors of bone are of the connective-tissue group, but various secondary tumors of epithelial origin may occur. Osseous tumors may arise from the periosteum or from the marrow. If they arise from the periosteum, they may extend early to adjacent soft tissues and involve and destroy them. If the tumor arises in the marrow, it is for a long while cut off from adjacent soft tissues by the thick cortex, and about the extending medullary tumor may also come a reactive proliferation by the periosteum, so that as the tumor extends it still may for a long while be surrounded by a shell of bone which prevents infection of the soft parts. After a time, however, the reactive periosteal shell usually becomes perforated at one or more points, and then the medullary tumor extends to the adjacent tissues.

The cause of these tumors, as a rule, is absolutely unknown. In certain cases, *e. g.*, some of the osteomata and chondromata, the tumor appears to take its origin from remnants of the provisional cartilage which precedes true bony formation, or from the persistence of parts of cartilage of the epiphyseal line.

The cause of the malignant tumors is absolutely unknown. Various theories as to the origin of the malignant tumors have been advanced, but no one of them at the present time has sufficient basis to be considered as well established. Some of the tumors, notably the sarcomata, frequently have been assigned to traumatism. It is true that malignant tumors often are first recognized subsequent to traumatism of various sorts, but when one considers the vast number of injuries to bones which are received, and the relatively small number of malignant tumors which occur subsequent to such injuries, it does not seem fair or just to assume that such tumor was caused by the injury. In many of the cases the tumor undoubtedly has antedated the injury, and has been recognized only when attention was called to the affected area by the traumatism. In no case is there any definite experimental evidence to show that injury alone can be assigned as an adequate cause of the origin of malignant tumors.

Fig. 36.—Skiagraph of Osteochondroma of Femur (Keen).

Fibromata are not very common tumors of bone. They arise generally from the periosteum, and are most common about the face and nose, bones of the skull, and rarely are seen in the long bones. About the nose and pharynx they may produce the so-called "nasal polyps." They also may arise from the alveolar process. Many of these tumors are closely allied to some of the fibrous forms of sarcoma, and it is often difficult to distinguish them histologically. Chief reliance must be placed in making a differential histologic diagnosis upon the relative frequency of mitotic figures.

Chondromata.—These are fairly common tumors of bone. They may appear externally to the cortex, or sometimes they grow in the medullary canal. They may arise directly from the marrow, probably from remnants of the provisional cartilage cells. They also appear frequently to arise from remnants of the epiphyseal line. They are most common upon the hands, and also occur frequently near the ends of bones.

Fig. 37.

Those which occur inside the cortex in some cases enlarge sufficiently to cause perforation of the cortex. They usually form nodular masses, oftentimes of large size; in most cases there are multiple tumors. In many cases, too, there seems to be a certain element of heredity in the occurrence of these tumors, various members of one family frequently being affected.

The chondromata are especially liable to undergo various forms of degeneration, such as myxomatous degeneration, or portions of the tumor may become calcified, and in some cases portions are ossified and converted into true bone.

Fig. 38.

Figs. 37, 38.—Exostosis Cartilaginea.
Both photographs from the same patient. Father and son of this patient had similar lesions.

Symptoms.—Chondromata appear generally as multiple nodular masses, most commonly on the hands, frequently on the lower leg about the knee-joint, and in other places, especially in the vicinity of epiphyseal lines, and oftentimes also affect the pelvis. In the latter position they often become of enormous size, and sometimes cause a fatal result from their size alone. They usually are painless and are firm and hard, and not tender to pressure.

Treatment.—Consists in removal by operation. In many cases the operation is trivial, but when the tumors are of enormous size, the operation becomes dangerous from purely mechanical difficulties.

Osteomata.—These are bony tumors which generally arise by growth of the periosteum, and form solid bony masses external to the cortex of the bone, when they are called "exostoses." Very rarely they rise from the inside of the bone and then are called "enostoses." The density of the bone composing the tumor varies a great deal, some being very hard and ivory-like; others like the cellular marrow of the long bones. Osteomata may be surrounded by a layer of fibrous periosteum, or in certain cases beneath the periosteum appears a layer of cartilage producing the so-called "exostosis cartilaginea." The latter formation is the one which is most common in the vicinity of the epiphyseal line of the long bones, notably of the leg. Sometimes such tumors are congenital; at other times they appear at a late period of life. They may be single or multiple. They appear, as do some of the chondromata, to arise from remnants of the epiphyseal line, and oftentimes form definite rows of bony, tumor-like masses.

FIG. 39.—SARCOMA OF HUMERUS (Keen).

Symptoms.—Osteomata form circumscribed hard nodular masses of bony consistency. They are usually painless. They may cause interference with function occasionally from their size, especially when they appear in close connection with a joint.

Treatment is removal. The tumors always tend to recur unless great pains are taken to remove them in their entirety, so that at the base of the wound of operation *no fragment of the original osteoma must be left.* If the bone is entirely removed, they do not recur.

Sarcomata.—These are the most common tumors of bone; they are malignant, and, when removed, tend to recur either locally or by metastases in different parts of the body. The metastases usually are distributed by the circulation. They may arise from the marrow (medullary sarcoma), frequently in the jaw bones, and in the marrow of the long bones. They arise generally in the epiphysis of the bone, and extend to the shaft only at a later stage of their development. As the tumor advances it causes a softening and an absorption of the original cellular marrow until it approaches the periosteum. In many cases the periosteum, as about any form of foreign body, then begins to proliferate, and forms a shell of periosteal bone surrounding the tumor. In that way the shell of the bone oftentimes becomes very much enlarged before there is any extension of the process through the shell to the adjacent soft tissue. By destruction of the marrow and of the cortex great softening of the bone may occur, so that spontaneous fractures not infrequently are seen.

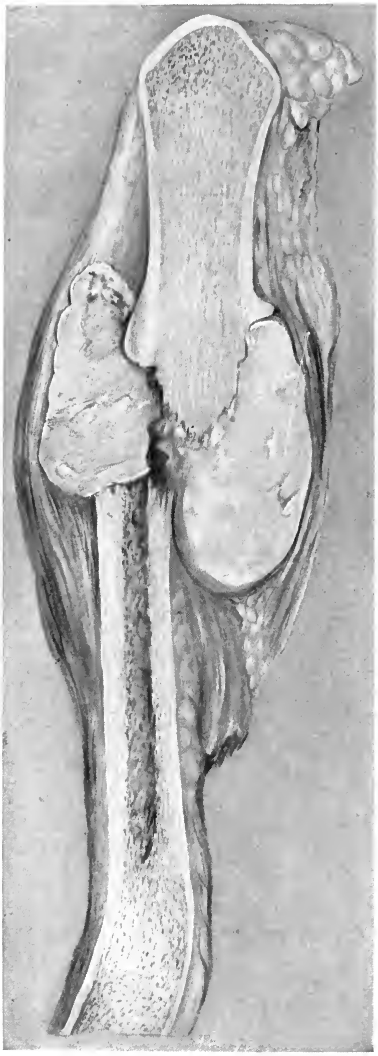


FIG. 40.—SARCOMA OF SHAFT WITH SPONTANEOUS FRACTURE. AMPUTATION AT HIP (Lund).

The cellular structure of the medullary sarcoma varies, producing different histologic varieties of tumor—either small or large round-celled sarcomata or fibrosarcomata. In many cases large giant-cells also are present, producing the so-called giant-cell sarcoma. At times there is also a new formation of bone, which may exactly resemble the trabeculæ of normal bone, but in many cases it is more like osteoid tissue. When bone is produced, the tumor is called an osteosarcoma.

Most sarcomata when they attain any considerable size undergo various regressive changes, either from necrosis or from hemorrhage leading to softening and destruction, oftentimes of a great portion of the original sarcomatous tissue. In certain cases the entire center of the tumor becomes softened and disintegrated, and only a small periphery of sarcomatous tissue is left, surrounded by a shell of new periosteal bone. At times the sarcomata have an alveolar structure. As a rule, from gross appearances alone it is impossible to make a diagnosis as to the histologic cell structure of any given sarcoma.

Other sarcomata arise from the periosteum. Any portion of the skeleton may be affected. Sarcomata which arise from the periosteum may be of any one of the cellular types of sarcoma, although fibrosarcomata often arise from the periosteum. The tumors usually originate from one side of the bone, although occasionally they entirely surround the bone. In the periosteal sarcomata a new formation of bone is common, and the bone is frequently arranged in a radial way, giving a most remarkable picture in dried specimens or in x-ray plates.

Myeloma is a very rare malignant tumor of bone. Such tumors always appear only in connection with bone, are usually multiple, and are of the same type as other lymphoid tumors. The cells of such tumors resemble very closely the type of the plasma cell (myeloplaque). The cells are arranged in masses without an intercellular substance, and the tumors are closely allied to the malignant lymphomata. The cases are always associated with albumosuria.

Symptoms.—The chief symptoms of malignant tumors of bone are swelling and pain, both of which oftentimes are extreme. In the medullary tumors the swelling may not be recognized until very marked advance of the process has led to dilatation of the cortex or to spontaneous fracture. In the periosteal varieties swelling, of course, may be recognized very much earlier. In the medullary type the swelling usually is spherical or spindle shaped. Extension to the joints may not occur for a great length of time. In the periosteal tumors the swelling usually is more asymmetric. In many cases x-ray examination is the most reliable method of detecting the character of the bony change. Exploratory operation is often necessary before a definite diagnosis can be made.

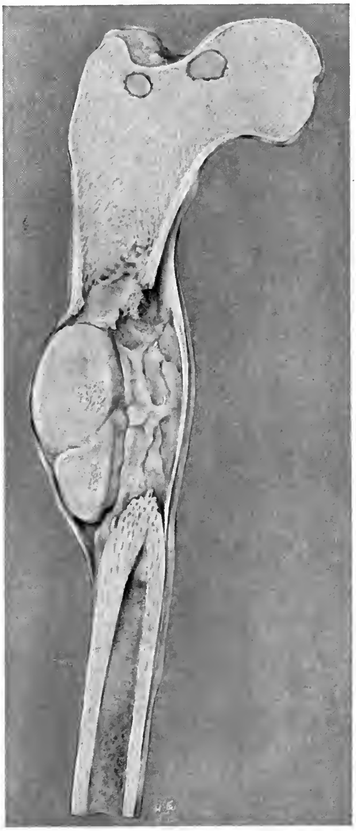


FIG. 41.—CANCEROUS METASTASIS IN SHAFT OF FEMUR WITH SPONTANEOUS FRACTURE (case of Dr. F. B. Lund).

Treatment.—The treatment of all sarcomata is early and complete removal. This means in nearly all cases amputation of the affected bone, and it is important that the amputation should be of the *entire* bone through the joint between the bone and the body, rather than amputation of the bone in continuity. The reason for this is that even in sarcomata which have not extended to the soft parts very frequently there have occurred metastases of tumor-cells throughout the blood sinuses of the affected bone, oftentimes at a distance of several inches from the site of the original primary tumor.

The prognosis after removal is very variable, being poorest in the round-cell type of sarcoma, and most favorable in the slowly growing fibrosarcomata.

Carcinomata.—Cancer of bone always is secondary to cancer in some epithelial organ. The extension of cancer to the bone may take place in one of two ways—either by direct extension from the primary tumor, *e. g.*, extension to the jaw from cancer of the lip, or to the ribs from cancer of the breast; or may take place by extension usually through the blood, or rarely through the lymphatics. An example of the blood extension is extension to the spine subsequent to cancer of the breast. The cancerous process at first usually brings about a destruction of the marrow-cells; the bony trabeculæ are destroyed only secondarily. Surrounding the cancerous area there often comes a new formation of bone, which arises usually from the endosteum of the adjacent trabeculæ or from the inner layer of the periosteum. The new bone formation in cancerous tumors, however, is usually very slight, and never is as marked as in many of the osteosarcomata. In the medullary cancers there sometimes is a very slight new formation of bone.

The extent of the destruction of the bone caused by cancerous infection varies very greatly. In many cases the secondary nodules are multiple and of small size. Occasionally, however, large areas of secondary metastatic cancer nodules appear in the shaft of the long bones, and may cause so much destruction of the shaft as to lead to spontaneous fractures; such cases are, however, rare.

Symptoms.—In cases of direct extension to the bone, as, *e. g.*, cancer of the jaw secondary to cancer of the lip, the symptoms of bone invasion may be entirely secondary to the symptoms produced by the primary cancer. In other cases the amount of pain is enormously increased after extension to the bone occurs.

In cases of metastatic invasions of bone, spontaneous fractures oftentimes are the first symptom which calls attention to the fact that metastases have occurred.

Treatment.—As in other malignant tumors, the indication is for absolute and radical removal wherever possible. Unfortunately, this is frequently impossible, because at the time the bone has become affected by extension to any great degree radical operation is impossible. Many times, however, extensive operations must be undertaken for the removal of bone. Occasionally amputations are required on account of fractures of bone due to metastases of the shaft.

Cysts of bone are rare lesions which occur practically always secondarily to other lesions. They may occur as the result of the degeneration and softening of bone sarcomata. Some of the cases of bone cysts undoubtedly represent the entire destruction of sarcomatous processes. Occasionally echinococcus cysts of bone occur. These appear as single cysts inclosing daughter cysts, and they may be single or multiple. They sometimes reach considerable size, and from pressure may cause a lacunar absorption of bone, with necrosis of the marrow in between the cysts.

Treatment.—Cysts of bone due to softening of the center of sarcomatous tumors are to be treated just like sarcomata themselves, *i. e.*, by complete removal, best usually by amputation. Cysts of bone not due to the presence of sarcomatous tissue should be opened and drained in some cases. Under those conditions cavities are left in the bone which can be closed in a variety of ways (*cf.* treatment of bone cavities under Osteomyelitis). Cysts due to the presence of echinococcus should be opened and drained, with a removal of every vestige of the echinococcus. In such cases it is to be remembered that the cysts may be multiple.

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CHAPTER XXIV.

FRACTURES.

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Definition.—The term fracture is derived from a Latin verb meaning to break. In surgery, a fracture means the breaking of a bone or cartilage.

Liability of Individual Bones to Fracture.—This varies greatly, as will be seen in the following statistics of over 38,627 fractures of all kinds.

From May 24, 1864, to December 31, 1905, there were at the Boston City Hospital* 38,627 fractures of all kinds. Of these, 34,994 were simple or closed fractures; 3633 were open or compound fractures; and 381 unclassified, the latter including various old and ununited fractures.

A. SIMPLE FRACTURES.

			Per Cent.
1.	Radius	4,657	(13.45)
2.	Humerus	3,517	(10.16)
3.	Ribs	3,196	(9.23)
4.	Femur	2,898	(8.37)
5.	Clavicle	2,756	(7.96)
6.	Fibula	2,344	(6.77)
7.	Metacarpus	1,285	(3.71)
8.	Tibia	1,259	(3.63)
9.	Skull	992	(2.86)
10.	Tarsus	947	(2.73)
11.	Phalanges (upper extremity)	798	(2.30)
12.	Inferior maxilla	692	(1.99)
13.	Patella	660	(1.90)
14.	Ulna	630	(1.82)
15.	Facial Bones	538	(1.55)
16.	Carpus	495	(1.43)
17.	Vertebræ	331	(0.95)
18.	Scapula	256	(0.73)
19.	Pelvis	208	(0.60)
20.	Metatarsus	168	(0.48)
21.	Phalanges (lower extremity)	78	(0.22)
22.	Superior maxilla	70	(0.20)
23.	Sternum	40	(0.11)
24.	Coccyx	20	(0.05)
25.	Hyoid	1	(0.002)
	Both bones of the leg	3,902	(11.20)
	Both bones of the arm	1,875	(5.10)

* I am indebted to Dr. D. D. Scannell, of the Boston City Hospital, for permission to publish these statistics.

B. COMPOUND FRACTURES.

			Per Cent.
1.	Skull	525	(14.45)
2.	Phalanges (upper extremity)	488	(13.43)
3.	Metacarpus	272	(7.48)
4.	Tibia	238	(6.50)
5.	Humerus	219	(6.02)
6.	Tarsus	203	(5.58)
7.	Carpus	152	(4.80)
8.	Femur	146	(4.01)
9.	Facial bones	119	(3.27)
10.	Phalanges (lower extremity)	69	(1.88)
11.	Inferior maxilla	66	(1.80)
12.	Radius	64	(1.70)
	Ulna	64	(1.70)
13.	Fibula	62	(1.70)
14.	Metatarsus	27	(0.74)
15.	Superior maxilla	10	(0.27)
	Clavicle	10	(0.27)
16.	Ribs	8	(0.22)
17.	Patella	7	(0.19)
18.	Pelvis	6	(0.16)
19.	Scapula	3	(0.08)
20.	Vertebræ	1	(0.02)
	Sternum	1	(0.02)
	Both bones of the leg	610	(16.70)
	Both bones of the arm	262	(7.02)

Considering the number of fractures by regions the statistics show:

			Per Cent.
Skull Face	Head	2,174	(5.60)
Spine Pelvis Coccyx Ribs Sternum Scapula	Trunk	4,070	(10.65)
Clavicle Arm Forearm Hand	Upper extremities	17,484	(45.50)
Femur Patella Leg Foot	Lower extremities	13,639	(35.60)

Influence of Sex, Age, and Season.—*Sex.*—Fractures occur more frequently in men than in women in the proportion of three to one. This is due to the larger number of males occupied in the industrial trades and similar pursuits in which there is increased liability to fractures. In middle life fractures are ten times as frequent in men as in women. In infancy and between fifty and seventy, the difference in sexes is slight, while after seventy fractures are more common in women.

Age.—Age also plays a rôle in the increased liability to fractures. In general they may be said to be most frequent in the first four decads of life.

Season.—Season affects the frequency of fracture only by increasing or diminishing the exposure to the accidents which cause them. The maximum is found in the summer months, when outdoor work, such as building, is more frequent. The minimum occurs in the winter, and fractures of the leg head the list of those of the winter months.

CLASSIFICATION OF FRACTURES.

Fractures are classified according to a number of different criteria as follows:

I. According to their degree.
II. According to the direction of the line of fracture.
III. According to their location.
IV. According to the etiology.
V. According to their relation to the overlying skin.
VI. According to the number of fragments.
VII. According to whether or not they are complicated.

Classification According to Degree.—A fracture which only involves a portion of the thickness of the bone, so that its continuity has not been entirely lost or a fragment has not been completely detached, is called an incomplete fracture.

A fracture which involves the entire thickness of the bone, so that it is divided into two or more distinct fragments, is called a complete fracture.

1. **Incomplete.**—(*a*) *Fissures.*—In these there is a split or crack in the bone. It occurs most often in the bones of the skull, and is very rare in the long bones, except when associated with complete fractures. The fissure may be quite long, and extend into the neighboring joint. A very long fissure is sometimes termed a longitudinal fracture (Fig. 42).

(*b*) *Infraction* (*Greenstick or True Incomplete Fracture*).—In the true infraction the conditions are similar to those observed when a green stick is bent, hence the name often given to it. The continuity of the bent bone is partially or completely interrupted. At the concave side of the bend the cortex is folded into a ridge, while at the convex side there is a separation (Fig. 42). This fracture is most frequently seen in the bones of the forearm, then in the clavicle, and very rarely in the bones of the arm, leg, or thigh. The great majority of cases occur under the age of fifteen years. A special form of infraction has been recently described by Kohl. The cortical layer upon the concave side of the bent bone is wrinkled or folded up. It is in reality the first stage of a true infraction or greenstick fracture. He observed it in three children between the ages of five and eleven years. If the force is greater or the individual is older, the convex side gives way and a true infraction occurs. This class of cases in which only a folding of the cortex occurs are of great interest from a diagnostic standpoint, as will be mentioned later.

(*c*) *Depressions.*—This variety of incomplete fracture usually occurs in the skull as a fracture of the outer table. It is occasionally seen in the extremities in connection with the complete variety, following a blow with a pointed instrument which causes the spongy portion to be driven inward.

(*d*) *Separation of a Splinter or of an Apophysis.*—In the first class a chip of bone is broken off, while in the second class a bony prominence or apophysis is torn off.

2. **Complete Fractures.**—These are divided according to the line of fracture and the seat of the latter.

Classification According to the Line of Fracture.—*Transverse.*—The line of fracture does not deviate more than ten to fifteen degrees from that of the transverse axis. This variety is rare in the shaft of the long bones. It is usually found at the lower end of the radius or of the femur and in the short bones.

Longitudinal.—Only two cases have been reported of this variety of the line of fracture.

Oblique.—This and the next form are the most frequent, in the shafts

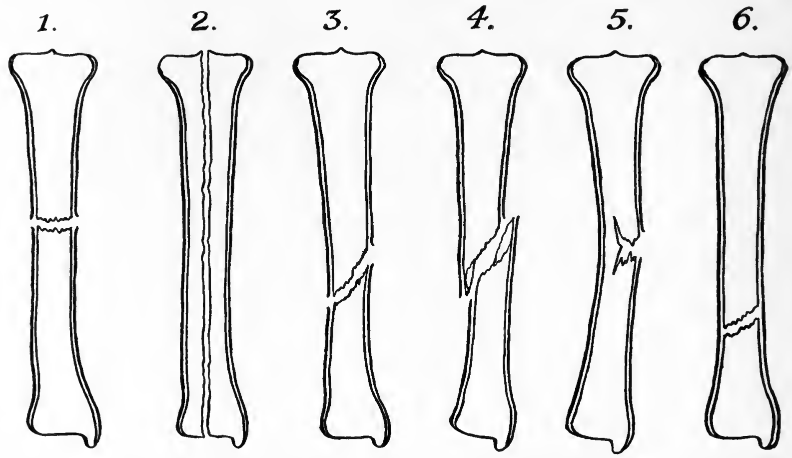


FIG. 42.—VARIOUS FORMS OF LINES OF FRACTURE.
1, Complete transverse; 2, longitudinal; 3, oblique; 4, spiral; 5, incomplete or greenstick; 6, subperiosteal.

of the long bones. In the oblique variety, the direction of the line of fracture may form any angle with the transverse axis of the bone up to a right angle. When it approaches the latter, it belongs to the group of longitudinal fractures. In the oblique variety, the line of fracture may be single or multiple.

Spiral.—This variety of the direction of the line of fracture was formerly considered to be very rare. The more systematic use of the x-ray as part of the routine of diagnosis has shown that spiral fractures are quite frequent in the shafts of the humerus, femur, tibia, and fibula. They will be referred to in detail under the appropriate heads. They are usually the result of a rotating or twisting force. The ends of the fragments in the transverse, oblique, and spiral varieties are usually more or less irregular. In some instances the toothed or dentate condition of the line of fracture may prove to be a serious obstacle to reduction.

Comminuted Fractures.—In this variety there is extensive splintering of the bone adjoining the fracture or of one of the fragments.

Impacted Fractures.—This variety usually occurs in the neck of the femur, at the surgical neck of the humerus (Fig. 110), and at the lower end of the radius. In the latter two instances the end of the shaft is forced through the soft expanded end of the bone. In the case of the neck of the femur the neck is either forced into the head or one portion of the neck into the adjacent part.

Compression or Crushing Fractures.—This variety usually occurs in the tarsal bones. The spongy portion and cortical layer are both crushed. In some cases there is a perfect pulpification of these bones (Fig. 214). This variety occurs after falls from a height upon the sole of the foot.

Subperiosteal Fractures.—Complete tearing of the periosteum all around the bone, along the line of fracture, is infrequent and is found only in fractures accompanied by great displacement of fragments. In the majority of fractures the periosteum is torn only along a portion of the line of fracture. A special variety of fracture has been described recently in which the periosteum is not torn, and the term subperiosteal fracture has been given to this variety. The diagnosis of these can only be made through the use of the x-ray, and will be referred to again. It is important to remember that such a fracture may exist, owing to the fact that static deformities, such as flat-foot, knock-knee, coxa vara, or coxa valga, may follow.

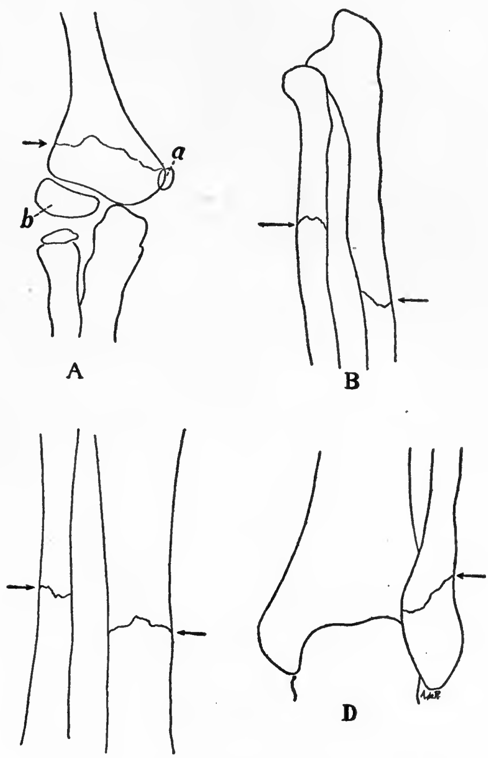


FIG. 43.—SUBPERIOSTEAL FRACTURES (after Lauenstein). A, Of the lower end of the humerus; *a*, internal condyle epiphysis; *b*, external condyle epiphysis. The arrow in all of the figures points to the seat of the fracture. B, Subperiosteal fractures of the ulna and radius; C, of the tibia and fibula at middle of shaft; D, of the external malleolus.

The direction of the line of fracture, as in the other forms of complete fracture, may be transverse, oblique, longitudinal, or even spiral.

Classification According to Their Location in the Bone.—Fractures are often referred to according to their relation to the shaft or some special point in a bone.

Those occurring in the diaphysis of a bone are spoken of as a fracture of the shaft, and if we wish to be more exact, we state whether it is of the upper, middle, or lower thirds. Fractures occurring at the ends of bones receive the name of the part which the line of fracture traverses, for example, fractures of the neck of a bone, of a tuberosity, of a process, of a condyle, etc. There are two forms of fracture which require special mention in connection with their location. These are epiphyseal separations and joint fractures.

Epiphyseal Separations.—The union of the epiphyses to the diaphyses commences during the period of puberty, hence these fractures are less common in childhood than after the ages of eleven or twelve. As a rule, they can only occur before the twentieth to twenty-first year.

The periosteum is tougher and more resisting during the early years of life than later on. It forms the chief bond of connection between the epiphysis and diaphysis at this period.

This variety of fracture will be referred to again (p. 93).

Articular Fractures (Joint Fractures).—These fractures, like epiphyseal separations, deserve special mention, since their recognition and proper treatment have assumed such great importance. Articular fractures may be divided into three classes:

1. *Intra-articular.*—In these the line of fracture lies entirely within the joint. Such joint fractures are most frequently found in the elbow- and knee-joint. In both of these localities they undoubtedly play an important rôle in the formation of free joint bodies.

2. *Para-articular.*—In these the line of fracture extends close to the joint, but not into it. An example of this class is the supracondyloid fracture of the humerus.

3. *Articular Fractures Proper.*—The majority of joint fractures belong to this class. The line of fracture either extends into the joint from without or it extends from the joint outward.

Examples of these true articular fractures are as follows:

In the shoulder-joint	Fractures of the glenoid cavity or neck of scapula. Fractures of the anatomic neck or of the tuberosities of the humerus.
In the elbow-joint	Fractures at the lower end of the humerus (p. 184). Fractures of the olecranon process.
In the wrist-joint	Fractures of the radius (Fig. 143). Fractures of the semilunar bone.
In the hip-joint	Fractures of the neck of the femur.
In the knee-joint	Fractures of the upper end of the tibia. Fractures of the patella. Rare cases of separation of one condyle of the femur or of T-shaped fractures (intercondyloid) of the lower end of the femur.
In the ankle-joint	The majority of the typical supramalleolar, malleolar, and spiral fractures of the tibia and fibula.
In the temporomaxillary joint	Fractures through the condyles of the lower jaw.

Those forms of epiphyseal separation just referred to, in which there is a line of fracture extending into the joint, are included in the above and require no special description. The etiology, diagnosis, and treatment of the various forms of joint fractures will be considered under the respective bones.

Classification According to Etiology.—Fractures may be divided according to their cause into two groups—the traumatic and the spontaneous or pathologic. In the former the fracture is the result of violence acting upon a bone which is either normal or shows slight changes due to the physiologic causes to be referred to.

A spontaneous or pathologic fracture is one which occurs in a bone the strength of which has been diminished by some preceding abnormal changes. In this variety the degree of force which produced the fracture would not be sufficient to cause a fracture in a healthy bone.

The Causes of Traumatic Fractures.—These may be either predisposing or exciting.

The Predisposing Causes.—The bones of the human body attain their greatest strength toward middle age. Up to that time the bones are very elastic and yielding, from infancy upward. Toward old age, an interstitial atrophy occurs. It causes a thinning of the cortex of the shafts, and of the trabeculæ of the spongy portions of the long and of the short bones. It is an actual diminution of the bone substance and a corresponding increase of the fat. This is especially seen in the neck of the femur. When it occurs in old age, it acts as a predisposing cause, but when it appears prematurely or reaches an extreme degree, it must be considered as pathologic.

Idiopathic fragility of bone, even when of inherited origin, is to be classed as a form of pathologic fracture (p. 86).

In early childhood and youth the presence of the epiphyseal cartilage between the epiphysis and diaphysis is an important predisposing cause, and instead of actual fracture, epiphyseal separations are more likely to occur.

Exciting or Determining Causes of Fractures.—Fractures occur as the result—(*a*) of external violence, and (*b*) of muscular action.

1. **Fracture by External Violence.**—These are divided both clinically and from a mechanic standpoint into two classes, viz., direct and indirect. In fractures by direct violence the bone breaks immediately under the point where the force has been applied. In this class there is more damage to the soft tissues and this damage is generally more serious than in indirect fractures. Direct fractures are more likely to occur in exposed bones like the clavicle, patella, olecranon, os calcis, etc.

Examples of fractures by direct violence are those of the clavicle, patella, or olecranon, which follow a blow or fall upon it, fractures of the tarsal bones after a fall upon the feet from a height, gunshot or saber fractures of the skull or of the bones of the trunk and extremities.

In fractures by indirect violence the force is applied at some distant point and is transmitted to the bone at the point of fracture.

Under the head of fractures by indirect violence belong—(*a*) those which occur after bending of a bone. The bone being fixed at one or both ends by muscular and ligamentous attachments, is bent beyond the limits of its elasticity and finally breaks. The convex side is the first to yield, and the fracture may only involve this side. To this latter class belong the various forms of incomplete fractures referred to on page 77. These are more apt to occur in childhood on account of the greater elasticity of the bones during this period.

If the bending force continues to act, a complete fracture follows.* Indirect fractures are in general more frequent in the long bones than in the short spongy ones.

(*b*) Those which occur as the result of a rotary or twisting force (fractures by torsion or spiral fractures). These occur after the resistance to torsion of a long bone has been overcome by a rotary force. When the end of the bone is fixed while the remaining portions are rotated, these fractures are apt to result. This class is represented by the spiral fractures of the humerus, femur, tibia, and fibula, which were formerly thought to be quite rare, but are now known to occur comparatively often (Fig. 196).

(*c*) Those which are produced by compression. This variety of fracture may occur either as the result of direct violence, such as was mentioned above, or following an indirect application of force. For example, a fall upon the feet may cause an impacted fracture of the upper end of the tibia (Fig. 193, *e*) or a fracture of the rim of the acetabulum (Fig. 173). Similarly a fall upon the outstretched hand may be followed by an impacted fracture of the lower end of the radius, or an impacted fracture of the upper end of the humerus (Fig. 110) or of the rim of the glenoid cavity. Instead of an impacted fracture, the compressing force may give rise to an articular fracture proper (p. 80).

(*d*) Those which are the result of a tearing force. This form of indirect fracture occurs when a joint is suddenly moved beyond its normal range of excursion. The firmly attached ligaments being a fixed point, the ends or some special process of the bones composing the joint are torn off from the remainder of the bone. Examples of this are fractures of the internal or external malleoli following forcible eversion or inversion of the foot, fractures of the greater or lesser tuberosities of the humerus after violent outward rotation of the arm. Many of the cases belonging to this variety of indirect fractures have been erroneously diagnosed as sprains before the systematic use of the *x*-rays.

2. **Fractures by Muscular Action.**—Fractures belong to this group when the action is exerted directly upon the bones by the muscles attached to them. They may occur (*a*) as the result of direct traction, as in fractures of the patella (p. 251), olecranon (Fig. 193), or of the tuberosity of the os calcis (Fig. 216). (*b*) As the result of a torsion of the limb against resistance. An example of this variety is the fracture of the shaft of the humerus occurring in the so-called "strength test."

* A third variety of fracture by bending is that which follows direct lateral pressure against the extremity of a bone in fixation, without actual bending at the seat of fracture, *e. g.*, fracture of the fibula by the pressure of the astragalus.

(*c*) By sudden muscular arrest of a rapidly moving limb, as in striking, throwing, or kicking at an object and missing it.

Gunshot Fractures.—These require special mention in the etiology of fractures. The greater the velocity of the bullet, the greater will be the destruction of the bone. Various conditions may result (Fig. 198), viz.: (*a*) It may cause a simple contusion or abrasion of the cortex; (*b*) it may cause a fissured incomplete fracture which usually does not extend into the joints; (*c*) the bone may be penetrated by the bullet without laceration of the bone; and the bone may break later upon being used; (*d*) there may be a number of fissures radiating from the wound of entrance and of exit, with or without comminution of the adjacent bone; (*e*) the bone may be completely shattered, causing extensive comminution; (*f*) there may be a gutter-like fracture. The more pointed the bullet, the more apt is the wound to be a clean-cut one.

The cortex of the shaft of the long bones offers more resistance than the spongy tissue toward the articular ends. Flat bones, like those of the skull, pelvis, ribs, and sternum, show a clean perforating wound. The same is true of the short bones of the body.

Clean-cut perforations without fracture are the rule in the neighborhood of the joints and epiphyses.

Intra-uterine and Intrapartum Fractures.—Fractures occurring in the fetus during gestation were formerly ascribed to external violence, but later investigations[1] show that the majority are the result either of amniotic adhesions or of some general cause, such as rachitis or syphilis.

It is generally agreed that it would require an immense amount of force to cause an intra-uterine fracture by external violence. They are not genuine fractures, but are infractions of the non-differentiated embryonic blastema. They are very frequently followed by a pseudarthrosis.

Fractures during delivery may be due either to external violence, such as traction upon an arm or leg, or to the fact that the limb which is broken is caught between the body of the child and the pelvis of the mother. The clavicle, humerus, or femur are most involved, and there may be an audible snap as the child is forced through the maternal passage. If the fracture involves the epiphyseal cartilage, the growth of the limb may be arrested.

Pathologic Fractures (Spontaneous Fractures).—In the majority of text-books on fractures these are spoken of as spontaneous. This is misleading, since the fracture is the result of two factors, viz., a pathologic condition of the bone which causes a lack of resistance, plus a trauma which may be either in the form of muscular action or of external violence. The two latter forms are characterized by the fact that the external trauma or muscular action is usually only a slight one.

Pathologic fractures may be divided according to their etiology into two groups, as Grunert[2] has shown:

I. Fragility of bone as the result of a local lesion.
II. Fragility of bone as the result of a general disease.

I. *Fractures resulting from bone fragility of local origin.*
  A. Through tumors.
    a. Primary and metastatic sarcoma.
    b. Metastatic carcinoma.
    c. Adenocarcinoma from the thyroid (osseous metastases).
    d. Enchondroma and benign osseous cysts.
    e. Metastatic hypernephromata.
    f. Echinococcus cysts.
  B. Inflammatory processes.
    a. Pyogenic osteomyelitis.
    b. Tuberculous osteomyelitis.
  C. Aneurisms.
II. *Fractures resulting from bone fragility due to some general disease.*
  A. Neuropathies.
    a. Tabes dorsalis.
    b. Syringomyelia.
    c. Mental diseases (paresis).
  B. Senile changes.
  C. Exhausting chronic diseases.
  D. Atrophy due to non-use.
  E. Scurvy.
  F. Rachitis and osteomalacia.
III. *Fractures resulting from idiopathic fragility of bone (osteoporosis, fragilitas ossium).*

I. *Fractures Associated with Local Lesions of Bone.*—A. *Tumors.*—The most common is the *primary sarcoma.* Pathologic fracture associated with metastatic sarcoma is rare. Of all collected cases of fracture due to a primary sarcoma, the femur was the seat in 56 per cent., the humerus in 21 per cent., and the tibia in 14 per cent.

The pathologic fracture may be the first symptom. Union very seldom occurs, Grunert being able to find only seven cases of pathologic fracture due to primary sarcoma in which union took place.

Of *metastatic carcinoma,* the majority of recorded cases of fracture have been associated with primary scirrhous carcinoma of the breast (60 per cent.). Of all metastatic carcinoma fractures, over half have been observed in the femur.

Fractures from Thyroid Tumor Metastases.—These are not frequent. They are most apt to follow malignant adenoma of the thyroid.

Fractures in Benign Bone Tumors.—These occur after enchondromata. Five such cases were reported by Gross.[3] Fracture is quite common, however, in benign bone cysts, thirteen cases having been reported, the majority occurring before the age of forty. A few cases have been recently admitted to the Cook County Hospital in which the fracture was due to a metastasis of a hypernephroma.

Echinococcus cysts in bone are rare. Only eighteen cases have thus far been recorded of pathologic fracture due to this cause.

B. *Fractures Associated with Inflammatory Processes.*—(*a*) *Pyogenic* *or Infectious Osteomyelitis.*—Considering the frequency of this lesion, pathologic fractures are unusually rare. This is probably due to the fact that the acute stage of bone destruction is followed by one of proliferation strengthening the bone.

(*b*) *Tuberculosis of Bone.*—Pathologic fracture in this lesion is even less frequent than in the pyogenic form. They are more common in the short bones and ribs than in the long bones. Repair in fractures due to pyogenic and tuberculous osteomyelitis takes place within the usual time.

(*c*) *In Syphilis.*—Pathologic fractures are relatively rare. Gangolphe collected 52 fractures in 39 cases, and to this number Grunert added 13 cases. They are most apt to occur late in the disease, the earliest case being six years after the initial lesion. The fracture is associated with little or no pain, as a rule. In exceptional cases the patients complain of excessive pain. The humerus is the most common seat of fracture, then the femur, clavicle, radius, tibia, ribs, and patella in the order named. Pathologic fractures have been frequently observed in hereditary syphilis, but only one case in the late hereditary form of the disease.

Fig. 44.—Skiagraph of Tabetic Fracture of the Os Calcis.

II. *Fractures Resulting from Fragility of Bone due to Some General Disease.*—A. *Neuropathies.*—(*a*) *Tabes Dorsalis.*—This is the most frequent cause of pathologic fracture due to the neuropathies. It may be the first symptom of an incipient tabes, but usually it occurs in the later stages of the disease. The trauma may be very slight and pain entirely absent. As a rule, the clinical picture of tabes is fully established when the fractures occur. In the majority of cases it occurs in the bones of the lower extremity. Union is slower than normal in about half of the cases. One of the chief-diagnostic features is the absence of pain. In the case shown in Fig. 44 the patient presented himself on account of inability to use the foot after a slight misstep accompanied by a painless swelling of the back of the foot. A skiagraph revealed a fracture of the os calcis. Examination of the general condition showed positive signs of tabes dorsalis. Tabetic fractures of these short bones show little tendency to consolidation.

(*b*) *Syringomyelia.*—Thirteen cases have been reported of a pathologic fracture due to this cause. The line of fracture is usually transverse. As in tabes, the fracture is painless; callus-formation is often excessive, but very slow. In syringomyelia the bones of the upper extremity are most often affected. The diagnosis of the cause can be readily made by an examination for the symptoms of the primary disease.

Fig. 45.—Fracture of the Middle of Shaft of Ulna in a Syphilitic Patient.

Union as shown in this skiagraph was greatly delayed on account of lack of ossification of the callus. This condition was immediately relieved by the administration of antisyphilitic remedies.

B. *Senile Changes.*—The changes which occur in bones during the later period of life have already been referred to (p. 81). This senile porosis and atrophy are seen especially in fractures of the neck of femur, but may occur in other bones (tibia).

C. *Exhausting Chronic Diseases.*—Cases have been observed of fractures of the ribs occurring in tuberculous patients after a severe spell of coughing. They have also been noted in patients suffering from diabetes and nephritis.

D. *Atrophy due to Non-use.*—When a limb has not been used for some time, no matter what the cause of the non-use, porosis and fragility of the bone occur. Union is usually not retarded in such cases.

E. *Scurvy.*—Eleven cases have been reported, all of them in infants. The fractures may be multiple of one bone, and are always associated with extensive swellings due to stripping of the periosteum from the bone by hemorrhagic exudate. Under proper treatment recovery and union occur.

F. *Rachitis and Osteomalacia.*—Pathologic fractures are a very frequent occurrence in rachitis. In osteomalacia there is great fragility of the long bones, and multiple fractures may occur without apparent cause and painlessly.[4]

III. *Idiopathic Osteopsathyrosis* (*Idiopathic Fragility of Bone*).—Doering has collected 79 cases in which pathologic fractures were due to this cause. In many it is a congenital condition. Most often, however, it appears during the first year of life and, without any ascertainable cause, affects previously healthy children. At times several generations of the same family are affected. The number of fractures which can occur in one individual varies greatly, the largest number being 200. The bones most often involved are the long bones of the extremities. The degree of pain varies from none to that of an ordinary fracture. Union occurs, as a rule, in less time than is usual in fractures. The etiology of the condition is unknown, the majority of writers believing it to be due to some disturbance of nutrition.

Classification According to Their Relation to the Overlying Skin.—Fractures are divided into *compound* or *open* and *simple* or *subcutaneous*, according to whether a communication does or does not exist between the seat of fracture and a wound of the skin. A *compound fracture* is one in which the cutaneous wound communicates with the seat of fracture. A *simple fracture* is one in which a wound of the skin is either absent or, if present, no communication exists between it and the seat of fracture. The majority of compound fractures are the result of direct violence, and the injuries of the soft parts are, as a rule, far more extensive and serious than in a simple fracture. A fracture which is simple at first may become compound as a result of necrosis of the skin, lying over it, or as a consequence of the original injury or of pressure upon it by a displaced fragment or by penetration of the skin, in efforts to use the limb.

The diagnosis and treatment of both simple and compound fractures are referred to under the respective heads.

Classification According to the Number of Fragments.—In the ordinary use of the term fracture, the latter is understood as a complete or incomplete separation of the bone into two or more fragments whose lines are continuous with each other.

The term *multiple fracture* is applied to the simultaneous fracture of two or more non-adjacent bones, and also to those cases in which two or more fractures of the same bone exist, and the lines are not continuous with each other. Such multiple fractures are usually the result of direct violence. Where fractures occur in two parallel bones like those of the forearm or leg or in two adjacent bones of the skull, the term multiple is not used.

Classification of Fractures According to whether Complications Exist.—When a fracture is accompanied by injuries of viscera, blood-vessels, nerves, etc., the term *complicated fracture* is applied. Such a fracture may be simple or compound. The term complicated, as ordinarily employed, is limited to those fractures which are accompanied by local, rather than by general, complications.

DISPLACEMENTS.

Displacement of the fragments of a fracture with relation to each other is present in the majority of cases. The degree of displacement varies greatly. It is absent in fissured fractures, in subperiosteal fractures, and rarely in complete fractures, even though the periosteum be torn. The varieties of displacements (Fig. 46) are the following:

1. *Transverse or Lateral Displacement.*—This may occur in a forward or backward direction or toward either side. It is usually associated with the angular or longitudinal (overriding) forms.

2. *Angular Displacement.*—This varies from a slight inclination of the fragments to each other to a right angle or more.

3. *Longitudinal Displacement (Overriding).*—This is most common in oblique fractures. It is most marked in fractures of the shaft of the femur, and is the result of muscular contraction.

4. *Rotary Displacement.*—One fragment, usually the lower, rotates on its long axis, while the other remains in position. It is frequent in fractures of the radius and femur.

5. *Displacement by Penetration or Crushing.*—This occurs at the

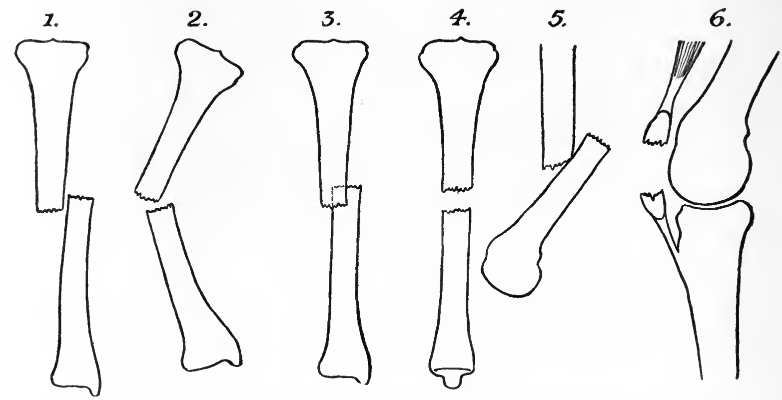


Fig. 46.—Various Forms of Displacement of Fragments in Fractures.
1, Lateral; 2, angular; 3, overriding; 4, axio-rotation; 5, overlapping and angular combined; 6, great separation of fragments.

surgical neck of the humerus, at the lower end of the radius, and in the neck of the femur as an impacted fracture. It is usually accompanied by more or less rotation of the fragments. This class also includes those fractures in which one fragment penetrates between two others, as in Y-shaped fractures.

6. *Diastasis or Longitudinal Separation.*—This is in reality a sub-variety of longitudinal displacement; the fragments do not override, but are pulled apart for a variable distance through muscular action. It is most frequently seen in fractures of the patella, of the olecranon, and in those of the tuberosity of the os calcis (Fig. 216).

SYMPTOMS OF A RECENT FRACTURE.

In the examination of a patient who has sustained a recent fracture the following routine should be followed:

1. The history of the patient and of the accident should be taken.

2. An examination made for objective signs, like deformity, abnormal mobility, crepitus, and ecchymoses.

3. Subjective symptoms, such as pain and loss of function of the limb.

4. The examination of a skiagraph taken with every possible precaution to exclude distortion or exaggeration (see page 90).

The History of the Patient and of the Accident.—The previous history is of the greatest importance where the trauma has been slight or if there is a possibility of the fracture being a pathologic one. The previous history is also of value in ascertaining whether the sequelæ of any previous accident (especially a fracture) exist in the form of deformity, etc. An exact account of the manner in which the accident occurred will enable one to judge of the degree of force employed and whether the fracture was the result of direct or indirect violence.

Objective Signs.—**Deformity.**—This is determined by inspection, palpation, and measurement of the injured part. One should always compare the results obtained by these tests with those of an examination of the non-injured limb or symmetric part of the body. In some cases inspection will at once reveal the presence of a fracture by an abnormal position of the limb or a visible deformity at the point of fracture. In other cases inspection is of little aid, and chief reliance must be placed upon palpation and measurement. Careful palpation aided by gentle manipulations will often reveal a distinct displacement of fragments. As in inspection, the injured side should be constantly compared during palpation with the sound one.

Measurement of the injured part is of great value if the bony points (Figs. 106 and 159) which are used as standards are not obscured by swelling and if the limbs are placed in the same position during the process of measuring them. In measuring the circumference of joints it must not be forgotten that there is often a normal difference of one-quarter to one-half of an inch between the two limbs. A circular measurement may be very unreliable on account of a rotary deformity.

Abnormal mobility of a bone at a point where it is not normally present is one of the most valuable signs of fracture. It is absent in the impacted and incomplete varieties, as well as in the intra-articular form. The methods of determining this sign are discussed in the section on special fractures.

Crepitus.—This sign, like that of abnormal mobility, is pathognomonic. It is a grating sensation, due to the rubbing of the broken ends upon each other. It resembles the previous sign by being absent in impacted, incomplete, and many articular fractures. It is also absent when a considerable separation or displacement of the fragments is present or when some foreign substance is interposed, like muscle, bone, etc., between the broken ends.

Ecchymosis, when it appears over a considerable area in a limb which has not been subjected to direct violence, is of great value as a sign.

Subjective Signs of Fracture.—**Pain.**—This is a constant accompaniment of a fracture. It is but little marked if there is considerable diastasis of fragments and if the fracture is impacted. It is of value if it is quite localized in fractures sustained by indirect violence, especially if most marked upon movement of the bone or pressing the ends together.

The pain of a fracture lasts, as a rule, much longer than in contusions or sprains. In fractures due to direct violence the injuries of the soft parts often obscure the pain in the bone.

Loss of Function of the Limb.—In many cases this is a valuable sign when taken in conjunction with the objective ones. In the majority of individuals there will be inability to use the limb. Exceptionally, however, one will find persons walking about on a fractured leg or using a broken arm.

x=Ray Examination.—This method has become one of the most valuable additions to our diagnosis of the injuries of both bones and joints. It serves the double purpose of confirming a diagnosis of fracture and of giving much information as to its exact nature. The *x*-ray should not be employed, however, to the exclusion of the other objective methods. It has the great advantage, especially in the case of fractures in deep-seated bones and in those close to joints, of enabling a diagnosis to be made at an earlier hour and with less manipulation than any of the other methods of diagnosis.

Every one should perfect himself in the examination of normal limbs by the ordinary methods of inspection, palpation, and mensuration. The examination of a fractured limb for deformity, abnormal mobility, and crepitus will then become more of a routine procedure, and the *x*-ray will then occupy its true position of confirming and amplifying a diagnosis previously made by the other methods. It is not only essential to have a knowledge of the body landmarks, etc., of the normal limbs, but of the appearance of the various bones and joints at all ages.

The normal epiphyseal cartilage looks to the novice like a fracture line (Fig. 47), so that one of the most valuable contributions to skiagraphy during recent years has been the study of the joints from infancy to the time ossification has been completed.[6]

It must be remembered that the amount of deformity as shown by the *x*-ray is often exaggerated, and seems far greater than appears to be the case by external examination.

For information in regard to the necessary time of exposure, the angle at which the picture should be taken, and other technical points one should consult the special treatises on this subject.

Method of Examination and Diagnosis of Fractures.—In the diagnosis of a recent fracture it is of the utmost importance to be both systematic and gentle. A knowledge of the applied or clinical anatomy of the region to be examined is of the greatest aid. Every practitioner should, if possible, be familiar with the results obtained by the examination of the surface anatomy of the human body during life. The normal range of motion of the various joints, the sensations derived from palpation and manipulations of the various bones in a healthy individual, is the most valuable preliminary education in the diagnosis of fractures and dislocations.

If this knowledge has not been previously acquired, one should repeatedly examine the corresponding normal part and compare the findings with those obtained from the examination of the injured one.

The order of examination can be varied according to the individual case. One to be suggested as of value is as follows:

Examination of the general condition for evidences of shock, loss of blood, or visceral injury. Under the latter may be mentioned pallor and other signs of internal hemorrhage, evidences of intrathoracic mischief (p. 158), such as cyanosis, dyspnea, etc., or symptoms of septic absorption from infected compound fractures, incipient peritonitis (p. 102), etc. These are considered again under complications and under the individual fractures.

Careful removal of the clothing so as to have complete exposure of the

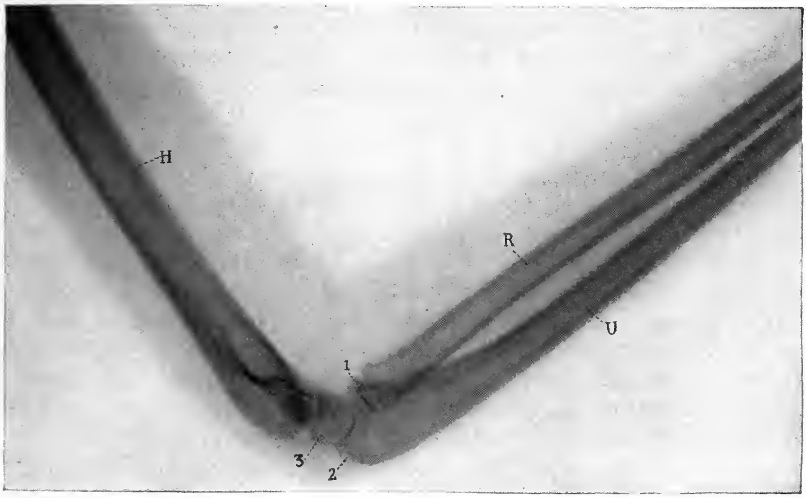


FIG. 47.—VIEW OF NORMAL ELBOW-JOINT OF A BOY TEN YEARS OF AGE.
R, Shaft of radius; U, shaft of ulna; H, shaft of humerus; 1, upper epiphysis of radius (capitellum); 2, epiphysis which forms the tip of the olecranon process; 3, lower epiphysis of humerus.

injured part. During its removal the region to be examined should be firmly supported, so as to avoid any unnecessary movement of the fragments. For fractures of the thorax, clavicle, humerus, scapula, and ribs it is best to remove all clothing as far as the waist. The examination can be best conducted while the patient is lying down. For special manipulations of the shoulder or elbow (pp. 164, 183) the patient can be asked to sit up. For fractures of the lower end of humerus, forearm, and hands all clothing should be removed on both arms as high as the shoulder. For fractures of the pelvis and femur the body should be exposed from the waist downward, the genitals in women being protected, if possible, or fractures of the patella, leg, and foot from the knee downward.

Inspection of the Injured Part.—This will assist in the recognition of deformity, swelling of soft parts or joints, ecchymoses, signs of injury to the vessels (p. 100), wounds of the skin, etc.

Palpation.—By this means the presence or absence of deformity, crepitus, abnormal mobility, of fluctuation in joints, pain, and tenderness can be elicited. Only very careful manipulation should be permitted in cases where an impaction is suspected.

x-Ray Examination.—In the majority of cases, especially when much swelling exists, this will save painful manipulation of the injured part and enable one to obtain not only evidences of the presence of a fracture or epiphyseal separation, but accurate knowledge of the details as to the position and number of fragments, etc.

We must, however, not accustom ourselves to rely upon this method to the exclusion of the older ones. Not every one who is called upon to treat fractures and dislocations has this means of diagnosis at his disposal. If possible, a skiagraph should be made of every case of suspected injury of bone, care being taken to avoid faulty exposure and incorrect interpretation of the picture. A knowledge of the *x*-ray appearance of the various bones and joints at different ages cannot be too strongly insisted upon.

Even with a good apparatus it is not always possible to obtain good pictures of fractures of the ribs, sternum, scapula, bones of the head, pelvis, and often of the neck of the femur.

Administration of an Anesthetic.—If a skiagraph can be obtained soon after the occurrence of a fracture or dislocation, the patient will not only be spared much manipulation, but the administration of an anesthetic becomes unnecessary for diagnostic purposes. In the absence of a skiagraph, and especially when marked swelling is present, and in children, anesthesia is almost indispensable in making a diagnosis.

History of Case.—This should, if possible, be obtained before the examination for suspected fracture is begun. Much information can be gained from the mechanism and force of the injury as to the probability of a fracture being present and its probable seat. It will also be of assistance in ascertaining whether the fracture is a pathologic one (p. 83).

Special points in the diagnosis of fractures to be mentioned are the following:

(*a*) The rough eroded surface of a dislocated joint after reduction will simulate bony crepitus.

(*b*) Apparent abnormal mobility in such bones as the ribs and in the long bones of children is often the result of the normal elasticity of the bones.

(*c*) In parallel bones, such as those of the ribs, forearm, metacarpals, leg, and in the metatarsals the ordinary signs of fracture, viz., crepitus, abnormal mobility, and deformity, are often indistinct and difficult to elicit. The same is true of the carpal and tarsal bones, as also of fractures where the fragments are dentated.

(*d*) An incomplete fracture is often overlooked until the presence of callus shows that injury to a bone has occurred.

(*e*) In impacted fractures deformity is often the only evidence of a fracture.

(*f*) Compound fractures should be manipulated as little as possible unless operative interference is indicated (p. 123).

(*g*) An incision to convert a simple into a compound fracture for diagnostic purposes is not good practice unless it has for its object the correction of the position of fragments, the relief of pressure on vessels or nerves, or a search for visceral injury.

Value of Objective Signs (Excluding x-Ray) in the Diagnosis of a Fracture.—If all the classic signs of fracture as described on p. 89 are present, the diagnosis is positive. All these signs may, however, be absent in incomplete or in subperiosteal fractures, in some of the articular fractures, and in epiphyseal separations without displacement.

Deformity is absent in transverse fractures and in those into joints. Abnormal mobility is absent in impacted fractures, or when one of two parallel bones are broken or if the fragments are dentated, and also in subperiosteal fractures. Crepitus is absent if there is an interposition of soft parts or if the fragments are widely separated (olecranon, patella, os calcis).

In some cases only two of the classic signs can be found, and in others only one.

Value of Subjective Signs.—Pain, if persistently located at the same point, is of value, especially in fractures by indirect violence. Disturbance of function is also a valuable sign if continued over a long period, and is not due to simulation.

The Diagnosis of Articular Fractures.—The diagnosis of all three varieties of articular fractures (p. 80) does not differ from that of other fractures of the long bones. The most characteristic symptom is the presence of an intra-articular effusion, usually bloody in character. This, taken in conjunction with the ordinary signs of fracture and an *x*-ray examination, will usually enable a diagnosis to be made. In cases in which the joint fracture is complicated by a dislocation (Fig. 290) the diagnosis is very difficult without an *x*-ray.

Special Features of Traumatic Epiphyseal Separations.—The long bones have a large epiphysis at each end of the shaft or diaphysis. The clavicle, metacarpal, and metatarsal bones and the phalanges of the hand and foot are an exception, having only one epiphysis. At birth the epiphyses are almost entirely cartilaginous, with the exception of the lower epiphysis of the femur and the upper epiphysis of the tibia. In the case of the long bones, the whole diaphyses are ossified at birth. They increase in length by the addition of bone at the junction of the diaphysis or shaft and the epiphyseal cartilage. The principal osseous centers appear gradually in the epiphyses of the long bones up to about the eighth year, each center having its own special time for appearance, as is shown in the accompanying table:

THE DATE OF OSSIFICATION OF THE CHIEF EPIPHYSES OF THE LONG BONES.

At birth	Lower end of the femur. Upper end of the tibia.
At 1 year	Upper end of the femur. Upper end of the humerus.
At 1½ years	Lower end of tibia. Lower end of humerus.
At 2 years	Lower end of the radius. Lower end of the fibula.
At 3 years	Great trochanter of femur. Great tuberosity of humerus.
At 4 years	Upper end of the ulna. Upper end of the fibula.
At 5 to 6 years	Upper end of the radius.
At 8 years	Lower end of the ulna. Lesser trochanter of femur.

Generally the consolidation between the epiphyses and shaft is completed at or soon after puberty, *i. e.*, sixteenth to seventeenth year, as will be seen in the accompanying table:

THE TIMES OF THE UNION OF THE EPIPHYSES TO THE DIAPHYSES OF THE LONG BONES.

At the 16th year	The upper epiphysis of the radius.
Between the 16th and 17th years	The olecranon epiphysis of the ulna.
At the 17th year	The lower epiphysis of the humerus.
At the 18th year	The internal epicondyle of the humerus.
Between the 17th and 20th years	The epiphyses of phalanges of toes.
Between the 18th and 20th years	The epiphyses of phalanges of fingers and lower epiphysis of ulna.
About the 20th year	The metacarpal epiphyses.
Between the 18th and 22d years	The upper epiphysis of the humerus.
Between the 19th and 23d years	The lower epiphysis of the radius.
Between the 22d and 25th years	The epiphysis of the clavicle.
At the 18th year	The lesser trochanter.
Between the 18th and 19th years	The great trochanter.
Between the 19th and 20th years	The metatarsal epiphyses.
At the 19th year	The epiphyseal head of the femur.
Between the 18th and 19th years	The lower epiphysis of the tibia.
Between the 19th and 21st years	The lower epiphysis of the fibula.
Between the 20th and 22d years	The upper epiphysis of the fibula.
Between the 21st and 22d years	The upper epiphysis of the tibia.
Between the 20th and 23d years	The lower epiphysis of the femur.

In the female the union takes place, as a rule, a little earlier than in the male: in the former, about the twenty-second year; in the latter, at the twenty-third or even as late as the twenty-fifth.

The frequency of epiphyseal separation varies considerably according to the age of the patient.

In some instances the union is not perfect until a considerably later period—up to the twentieth year, and often until the twenty-fifth year in the irregular bones of the body.

At the elbow-joint injuries cannot be complicated by epiphyseal separation after the eighteenth year, while in the knee, epiphyseal separation of the tibia is possible up to the twenty-first year.

The epiphyseal or conjugal cartilage is a disc left by the ossification of the epiphysis, between it and the diaphysis. It disappears at the time of union of the epiphysis and diaphysis, by ossification. The epiphyseal line of junction is more or less transverse in infancy, but as age advances the under surface of the epiphysis in many of the long bones becomes cup-shaped, either projecting laterally, as at the lower end of the humerus (Fig. 43, *a*), or anteriorly, as at the upper end of the tibia. Although by reason of its softness the conjugal cartilage predisposes to epiphyseal separation, it facilitates the growth of the bone and aids it in escaping injury during the many falls incidental to this time of life by its flexibility.

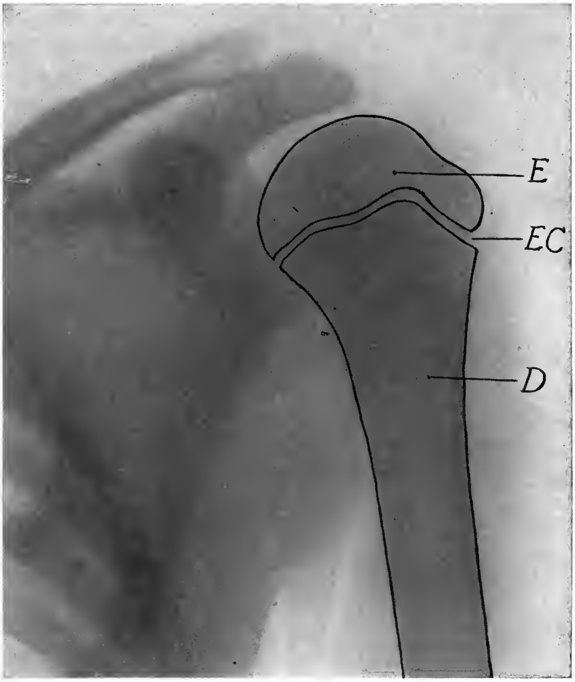


Fig. 48.—Shoulder-joint in Boy of Ten.
E, Upper epiphysis; EC, epiphyseal cartilage; D, shaft.

The juxta-epiphyseal region is the soft spongy layer of the diaphysis uniting the latter with the conjugal or epiphyseal cartilage. It is the weakest part of the bone, and the one which first gives way to external violence. Epiphyseal separations are, however, less frequent than they might be on account of the great support given at the epiphyseal lines of junction by the thick and strong periosteum, which is tougher and more resisting during the first few years of life than later on.

Etiology of Epiphyseal Separations.—Pathologic Separations.— A slight violence applied to an epiphysis of a child or a young adult with some constitutional affection is often sufficient to cause its separation, without producing any displacement. The diseases in which such separations are likely to occur are rickets, marasmus, syphilis, scurvy, and septic conditions. Of these diseases, rickets is the most frequent cause.

Traumatic Separations.—*Indirect violence* is the most frequent cause of detachment of a true or osseous epiphysis, and it is generally of a severe character. Examples of such indirect violence are—(*a*) direct traction on the axis of the limb either during birth or at a later period; (*b*) fall from a height, the force being transmitted from the distal end of the limb, such as a fall upon the hand; (*c*) entanglement of a limb in the revolving wheel of a vehicle. This is one of the most frequent causes of epiphyseal separations at the elbow or knee; (*d*) fixation of the entire limb or of only a part of it while the rest of the body is thrown violently in one or the other direction; (*e*) forcible hyperflexion or hyperextension of a joint, especially of the knee or elbow, will also readily effect a separation.

Direct Violence.—This is a common cause of separation of the epiphysis at all periods. Examples of this are the passage of a wheel over the limb or severe violence applied directly to the epiphysis, as from the fall of a heavy weight upon the part. Violence applied in the neighborhood of a joint in children is much more likely to be followed by an epiphyseal separation than a fracture.

Muscular Action.—Violent movements in children, which in an adult cause a stretching or laceration of the ligaments or even detachment of bone into which these are inserted, produce epiphyseal separations in children. Ollier groups under the name of juxta-epiphyseal sprains various lesions of the spongy layer of the end of the diaphysis.

Age.—From statistics collected by Poland[62] it is clearly proved that epiphyseal separation is less common in early childhood than after the age of eleven or twelve. As a rule, it can occur only before the age of twenty to twenty-one. In certain epiphyses union is not complete before the twenty-fifth year (see table on p. 94), and in these it may occur later.

Frequency of the Various Separations.—Poland has collected over 700 cases of epiphyseal separation. The order of frequency of these is as follows:

1. Upper epiphysis of the humerus.
2. Lower epiphysis of the femur.
3. Lower epiphysis of the radius.
4. Lower epiphysis of the humerus.
5. Lower epiphysis of the tibia.
6. Upper epiphysis of the tibia.

Epiphyseal separations, like fractures, may be incomplete or complete. In the majority of cases the cartilage drags with it more or less of the osseous tissue of the diaphysis. The incomplete separations are also called juxta-epiphyseal sprains, and are often overlooked.

Epiphyseal separations have not been known to take place before birth, but a number of cases in which they occurred during birth have been recorded.

Site and Varieties of Separation.—The separation most frequently occurs above the epiphyseal cartilage, and is in reality a fracture of the end of the diaphysis, a thin layer of the ossifying tissue of the latter still clinging to the cartilage.

Epiphyseal separations, like true fractures, may be either complete or incomplete. To the latter the name juxta-epiphyseal sprains is given.

Complete Separations.—The displacement of the epiphysis may be completely away from the diaphysis (Fig. 49). The liability to displacement varies not only with the direction and amount of the violence, but with the epiphysis involved. It is greatest in those with an oblique or a flat surface.

FIG. 49.—X-RAY OF FRACTURE THROUGH THE LOWER EPIPHYSIS OF THE HUMERUS IN A CHILD OF THREE.

The outlines of the bones have been strengthened by tracing them in black. RS, Shaft of radius; R, upper epiphysis (capitellum) of radius; US, shaft of ulna; E, lower epiphysis of humerus displaced inward; H, shaft of humerus.

Incomplete Separations.—These are much more common than complete separations. They are very common, especially in younger children, and usually diagnosed and treated as sprains. The history of many cases of arrest of growth of bones is that the injury had been considered a sprain. Epiphyseal separations are frequently complicated by a fracture at the end of the diaphysis (Fig. 143) or a fracture of the epiphysis. Pure separation, without involvement of the diaphysis, is the exception.

Complications of Epiphyseal Separations.— 1. *Fracture of the Epiphysis Passing into the Joint Itself.*—This occurs most often at the lower end of the femur, then at the lower end of the humerus, and least often at the lower end of the radius.

2. *Fracture of the Diaphysis.*—The epiphyseal separation not infrequently passes for a greater or less extent through the level of the epiphyseal cartilage, and then runs vertically or obliquely upward through a portion of the diaphysial end (Fig. 143).

3. *Injuries to Blood-vessels.*—These are much more frequently injured through pressure or laceration by the displaced end of the diaphysis than in fractures at the corresponding part. This complication occurs most often in epiphyseal separation at the lower end of the femur.

4. *Injury to Nerves.*—This is not very common, but has been observed at the lower end of the femur and both ends of the humerus

Symptoms and Diagnosis of Epiphyseal Separations.—Separation with Displacement.—*History of the Injury.*—This is of great importance, often suggesting the possibility of an epiphyseal separation.

Age.—The period during which they are most likely to occur is between twelve and twenty.

Mobility.—This is the only symptom upon which reliance can be placed. Such abnormal mobility at the level of the epiphyseal cartilage is a most certain sign. In some cases it will be less distinct on account of the impaction of fragments, or from the fact that there is a more or less extensive fracture of the diaphysis (Fig. 143).

Deformity.—This will vary according to the displacement of the diaphysis. In many the tendency to displacement is slight. When marked, the osseous projection of the diaphysis appears as a distinct ridge to be felt beneath the skin. It feels more or less smooth, regular, and uniform, unlike the rough and irregular projection of true fractures. In the case of the upper end of the humerus a cup-like hollow has been felt on the inferior aspect of the epiphysis. In separation of an epiphyseal process the exact form of the normal epiphysis may be recognized in the detached fragment.

Crepitus.—There is no true bony crepitus. It is an indistinct, dull, soft grating of a muffled character. This is especially the case in younger infants, while in older children the crepitus will be more like that of a true fracture, especially if there is an accompanying fracture of the diaphysis.

Pain at the diaphysis-epiphyseal line is of great value when present.

Swelling of the Joint.—This is usually very marked, causing considerable enlargement and giving rise to great pain.

Ecchymoses and Swelling of the Soft Parts.—These are very extensive and obscure the outlines of the bones.

x-Ray.—This, as in true fractures, is of the greatest aid, but a correct interpretation requires familiarity with the conditions in children at different ages (Figs. 147, 148). It is also advisable to take pictures in several directions and compare them with those of the uninjured side.

Separation without Displacement (Epiphyseal Sprains).—The symptoms of this condition are so few and uncertain that they are either overlooked or regarded as sprains.

The signs are—(*a*) pain and tenderness on pressure about and along the epiphyseal line; (*b*) contusion or ecchymosis about the joint; (*c*) loss of power of the limb; (*d*) mobility, often slight; (*e*) rigidity of the limb on account of the pain caused by movement.

Epiphyseal separations differ from fractures in many particulars: (*a*) The shape of the displaced epiphyseal fragments is often quite unmistakable. (*b*) The deformity is very characteristic, especially at the upper end of the humerus. (*c*) Crepitus is soft and smooth unless the diaphysis has also been broken.

From a dislocation, an epiphyseal separation can be distinguished by the facts that (*a*) dislocations are very rare in infancy and early childhood. (*b*) Moderate traction will restore the displaced fragments to their natural position in an epiphyseal separation, but when the traction is discontinued, it will recur. In a dislocation there will be but little tendency for the displacement to recur. (*c*) The deformity is often quite similar to that of dislocation, but palpation of the projecting diaphysis will show it to differ from that of the articular end. (*d*) Abnormal mobility is also quite characteristic of an epiphyseal separation. (*e*) By measurements between the bony points of the two or more bones composing the joint. In dislocation the measurements will be altered; in epiphyseal separation, as a rule, they will be unaltered.

If the swelling is too great to permit of manipulation and palpation, an anesthetic should be given. A more careful examination can then be made. A skiagraph will often avoid even the use of an anesthetic.

Compound epiphyseal separations must be differentiated from compound dislocations or compound fractures close to or into joints. This can be readily done by a skiagraph combined with examination of the wound after the employment of every possible means to avoid septic infection.

COMPLICATIONS OF FRACTURES.

The following are the chief complications which occur during the clinical course of a fracture:

Disturbances of the Skin.—Trophic disturbances may take place either during the first few days or at a later period. At the former period bullæ are frequently seen, especially in fractures of the leg, and may be an atrium for infection. Interference with the growth of the nails and, at a later period, eczema and various other cutaneous eruptions, have also been observed and ascribed to trophic nerve changes.

The skin may be extensively contused, especially in fractures by direct violence. The injured skin may entirely recover its integrity or gangrene may follow. This is especially apt to occur after compound fractures.

Gangrene of the skin may also be the result of injury of an artery or vein (see below), or be due to the pressure of a fragment upon the overlying skin. In the latter case, necrosis of the skin occurs within a first week unless the pressure has been relieved during the first twenty-four hours.

Thrombosis and Embolism.—Not infrequently thrombosis of the deep veins of the lower extremity occurs in fractures of the tibia and fibula or of the patella or the femur. A marked swelling of the entire limb occurs, which is far greater than that ordinarily accompanying such a fracture. It has been observed for the first time after a cast has been removed and the patient permitted to walk. In a few cases an embolus has been detached and has produced pulmonary embolism. The most marked symptoms of such a condition are great dyspnea, rapid pulse and cyanosis, often resulting fatally within a short period. It is most apt to occur in elderly male patients. Lotheissen has collected 36 cases of pulmonary embolism with 30 deaths. The majority were simple fractures, only 2 being compound. Twenty-five were of the leg, 7 of the femur, 3 of the humerus, and 1 of the patella. There is no symptom which is of value in recognizing the presence of such thrombosis, but its possibility must always be borne in mind in elderly people, especially if marked swelling exists.

Injuries to Arteries and Veins.—These may occur as a complication of both simple and compound fractures, either as the result of a spicule of bone penetrating the vessel-wall or be due to the pressure of a displaced fragment causing necrosis of the vessel-wall. The vessels most frequently injured in the various fractures are as follows:

1. Fractures of the clavicle—subclavian artery and vein; internal jugular vein.
2. Fractures of the humerus—brachial and axillary arteries.
3. Fractures of the ribs—intercostal vessels.
4. Fractures of the pelvis—iliac vessels (external and internal).
5. Fractures of lower end of femur—popliteal artery and vein.
6. Fractures of tibia—popliteal and anterior tibial arteries.

In the extremities, injury to an artery will either result in the formation of a traumatic aneurism or in gangrene of the limb. In arteries adjacent to large cavities, such as the thorax or abdomen, either a traumatic aneurism will form or a fatal internal hemorrhage occur.

Injury to a vein, if the latter has been penetrated, results in extensive hemorrhage into the tissues or externally, if the fracture is a compound one. If the vein has been compressed by a displaced fragment, thrombosis with resulting gangrene of the limb occurs. The recognition of an arterial injury depends—(1) upon certain primary symptoms which immediately follow the accident, and (2) other so-called secondary signs, appearing later. (1) The primary symptoms are—(*a*) a rapidly increasing swelling which pulsates after it has ceased to enlarge; (*b*) the absence of pulsation in the peripheral vessels of the cold and pale limb; (*c*) a rough, rasping murmur synchronous with the pulse and due to the projection of a thrombus into the lumen of the vessel; (*d*) rapidly increasing signs of anemia.

(2) The secondary or late evidences of arterial injury are the appearance—(*a*) of a traumatic or false aneurism; (*b*) of signs of gangrene of the limb, and (*c*) the occurrence of severe secondary hemorrhage, usually about the sixth to ninth day.

A traumatic aneurism can be recognized by the appearance of a swelling in the vicinity of the fracture, which has an expansile thrill and a blowing soft systolic murmur.

The signs of gangrene following arterial or venous injury do not differ from those observed under other conditions (see Vol. I, pp. 318, et seq.).

If both the artery and vein are injured, a rather rare occurrence, the early symptoms are the same as when the artery alone has been injured, except that there is an increased amount of edema of the limb. Later on this becomes very marked, and is accompanied by a continuous murmur transmitted in a proximal and distal direction, both in the artery and vein. There is also a distinct venous pulsation, and the superficial veins become varicose.

Injuries to Nerves.—These may be either the result of a contusion of the nerve and the loss of function be incomplete, or the nerves may be so compressed or even torn that their function is completely lost. The nerves most likely to be injured are:

1. Fractures of the clavicle—brachial plexus.
2. Fractures of the humerus—circumflex, median, ulnar, and musculospiral nerves.
3. Fractures of the fibula—peroneal nerve.

The nerve may be either severed completely at the time of the accident, or be interposed between fragments or be compressed by a displaced fragment or by a callus (Fig. 50). The diagnosis of such nerve injury may be made from the following specific signs:

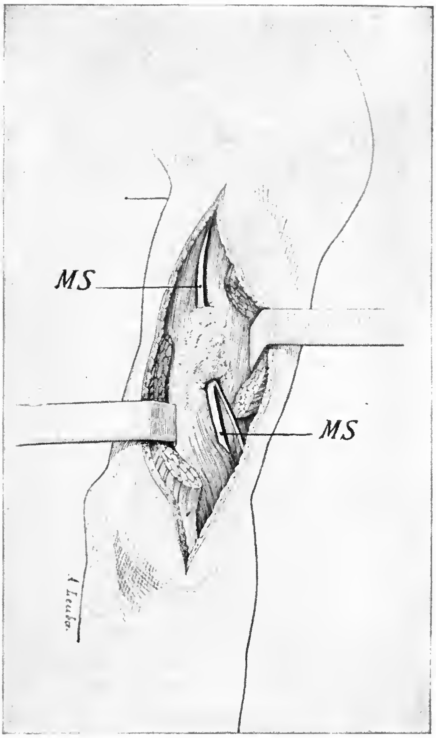


Fig. 50.—Musculospiral Nerve Compressed by a Callus Resulting from a Fracture in Middle of Shaft of Humerus (Lejars).
MS, *MS*, Musculospiral nerve above and below point of compression by callus.

(*a*) Paresis or paralysis of the muscles supplied by the nerve.

(*b*) Disturbances of sensation in the cutaneous area supplied by the nerve. There may be simple paresthesia or complete anesthesia. The extent of the latter seldom corresponds exactly to the area supplied by the affected nerve. This is due to the fact that neighboring nerve filaments often assume the function of the sensory endings of the injured nerve. If the nerve is compressed by a callus, there is often severe pain along the course of the nerve.

(*c*) Vasomotor and trophic changes. The former cause redness and local rise of temperature, followed gradually by cyanosis and coldness. The skin becomes smooth and shiny, and loses its elasticity. There are marked muscular atrophy and stiffness of the joints.

(*d*) Changes in electric reaction. If the nerve is completely severed, there is an absence of response to both galvanic and faradic stimulation after the second week. The affected muscles show an absence of faradic, but an increase of galvanic, reaction.

(*e*) The appearance of a tumor at the seat of injury as the result of the formation of a neuroma where the nerve has been contused or injured.

Fat Embolism (Vol. I, p. 462).—Small amounts of fat are carried into the circulation in every case of fracture. In the majority of cases fat emboli produce no symptoms. In rare instances the fat emboli lodge in the brain, lungs, and kidneys, giving rise to serious symptoms and in some cases causing death. Fat embolism is more apt to occur after simple than compound fractures, probably owing to the lack of drainage in the former.

In the lung the fat infarcts are followed by edema and bronchopneumonic areas. The symptoms of fat embolism resemble those of shock, but begin a little later. In some cases pulmonary symptoms, such as rapid breathing, dyspnea, and coarse râles, predominate. In others there are marked cerebral symptoms, such as coma, muscular twitchings, slow stertorous breathing, etc. Fat in the urine is an almost constant accompaniment of fractures, but does not give rise to symptoms.

Septic Complications.—These may be either local or general. Infection occurring at the site of a simple fracture is exceedingly rare. It is most apt to occur in cases of compound fracture or where gangrene has occurred as the result of injury to the blood-vessels of a limb.

The organisms which produce infection under these conditions, especially in compound fractures, are the ordinary pyogenic forms (staphylococcus pyogenes aureus and albus and streptococcus pyogenes).

In addition, infection with more virulent organisms, such as the bacillus of malignant edema and bacillus aërogenes capsulatus, is not infrequent. Finally, tetanus may occur, especially in compound fractures of the hand and forearm.

The local signs of infection with the ordinary pyogenic organisms in compound fracture are marked redness and infiltration of the skin in the vicinity of the wound, an increase of pain at the seat of fracture, and the escape of pus from the wound itself. The general symptoms vary with the intensity of the infection. In the majority of cases there is a rise of temperature and pulse, accompanied by symptoms of mild septic intoxication, such as malaise, headache, anorexia, and pallor. From these milder forms to the more severe ones in which the symptoms of a septicemia or septicopyemia predominate over the local signs of infection, all grades occur. The symptoms of septicemia do not differ from those produced by infection of other tissues, and are fully discussed elsewhere (Vol. I, p. 560). The same holds true for the symptoms of other septic complications, such as erysipelas and tetanus. Two forms of infection occurring in compound fractures require special mention, viz., emphysematous cellulitis and malignant edema. In the majority of text-books no distinction is made between emphysematous cellulitis produced by the bacillus aërogenes capsulatus of Welch and Nuttall and the rapidly spreading gangrenous form of infection due to the bacillus of malignant edema. They are both apt to complicate compound fractures, especially of the forearm. They are characterized by a hemorrhagic exudate and the development of gas in the tissues. Both forms of infection may be recognized clinically by the following signs:

(*a*) There is a rapidly spreading discoloration of the limb, accompanied by marked swelling and early gangrene.

(*b*) There is crepitation on pressure from the formation of gas in the tissues.

(*c*) Foul-smelling hemorrhagic exudate escapes from the wound.

(*d*) Marked septic symptoms appear early, such as high temperature, rapid pulse, delirium, and marked leukocytosis.

Death may occur within a few days unless an amputation is performed. The diagnosis of which of the two organisms is concerned can be made only by cover-slip preparations of the bloody serum and cultures on anaërobic media.

Delirium Tremens and Traumatic Delirium.—Hallucinations of vision, muscular twitchings, restlessness, muttering delirium, and a rapid pulse are frequent and often fatal complications of fractures in alcoholics. When the same group of symptoms occurs in persons suffering from a fracture who are not addicted to drink, the condition is known as a simple or traumatic delirium. It is most apt to occur in children and in elderly persons. If the symptoms enumerated exist more than a few hours after an injury, other causes should be sought for, such as great loss of blood, septic infection, anuria, acetonemia, iodoform absorption, or senile atrophy of the brain in the aged. If these can be excluded, the case must be considered as one of true nervous traumatic delirium. The chief symptom is a low muttering delirium without fever. Its etiology is not quite clear.

The recognition of delirium tremens is not difficult. Quite rarely the condition begins suddenly after a severe loss of blood. Most frequently the onset is gradual. The patients, who are at first restless, begin to complain of inability to sleep and show marked tremors of all muscles. There is soon total insomnia, accompanied by hallucinations and incessant muscular activity. If high fever is present, one must suspect the coëxistence of sepsis or of a pneumonia. The symptoms gradually increase until death occurs.

Shock and Hemorrhage.—Both of these conditions may be present as complications of fractures. In simple fractures shock is most apt to occur in those of the thorax, pelvis, or lower extremities. The symptoms of both of these conditions bear a great resemblance to each other, and in many cases, especially of extensive compound fractures, they coëxist. The diagnosis of both of these complications is discussed elsewhere (Vol. I, p. 936).

Pulmonary Edema and Pneumonia.—Pneumonia appears either as an early complication in a lobar form or later as a hypostatic pneumonia. Both are most apt to occur in elderly people, and especially in alcoholics. The lobar or early type pursues a rapid and severe course, with high fever and delirium. In the late or hypostatic form the symptoms appear gradually a few weeks after the fracture. The temperature is only a little above normal, and there are stupor and a rapid pulse.

THE REPAIR OF FRACTURES.

The healing of a broken bone does not differ greatly from that of other tissues, the only difference being that the end process is not the formation of cicatricial tissue, but a substance closely identical with the original bone (see Vol. I, p. 391).

When a fracture occurs, the broken ends are rough and more or less separated. It was formerly believed that the periosteum was torn all around the bone. Ollier was the first to show that this is not the case in the majority of fractures. More or less of the periosteum in the

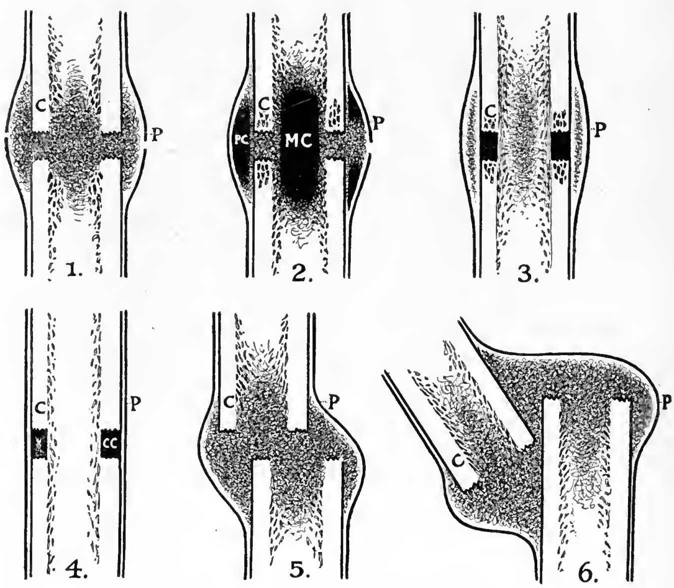


Fig. 51.—Various Stages and Degrees of Callus Formation.

1, First ten days. Formation of young connective tissue between broken ends. 2, Second and fourth weeks. Ossification takes place in medulla and from periosteum. If the periosteum remains untorn, it begins uniformly over the broken ends, as shown at pc. If the periosteum is torn, it begins at the periphery where the periosteum is still attached (P). 3, Formation of callus in cortical portion of bone after rarefaction of cortex by osteoclasts. 4, Normal bony union completed: cc, cortical callus, periosteal callus having been completely absorbed. 5, Formation of callus in cases of lateral displacement of fragments. 6, Formation of callus in case of angular displacement. In all the figures the letter C represents cortex; P, periosteum; pc, periosteal callus; MC, medullary callus.

shape of a periosteal bridge remains untorn and maintains a connection between the fragments. The muscles and other soft tissues around the seat of fracture are also torn, so that the latter is surrounded by considerable extravasated blood. This begins to be absorbed after a few hours and is replaced by a celluloplastic exudate which is composed of young connective-tissue cells. Granulation tissue now begins to be formed from this exudate as well as from those portions of the periosteum which have been stripped off and from the periosteal bridge. Thus the broken ends of the bones become temporarily united by granulation tissue formed chiefly from the periosteum and medulla.

This jelly-like and ovoid mass of tissue is called the temporary or provisional callus. This entire callus is gradually converted into osseous tissue. This process of ossification begins on the under side of the periosteum, and the greater portion of the new bone is formed by the bone-forming cells or osteoblasts of the periosteum. In the medulla the ossification begins from the inner aspect, the new lamellæ of bone entirely occluding the canal. The medulla helps but little in the formation of new bone in proportion to the amount formed by the periosteum; ossification of the granulation tissue or provisional callus uniting the broken ends begins on the twelfth to fifteenth day. The cortical portion of the bone is the last to take part in these changes. It undergoes a process of rarefaction which soon ceases and is followed by one of condensation, so that the cortical layers of the two fragments again become united by lamellæ of bone. The excess of periosteal and medullary new-formed bone is gradually absorbed, so that the original continuity of the bone and medullary cavity is restored. The various stages are shown in Fig. 51. They are:

Fig. 52.—Skiagraph of Multiple Fractures of Upper Third of Humerus. Note the callus (Manges, Jefferson Med. Coll. Hosp.).

1. Extravasation of blood between the ends of fragments and torn periosteum.
2. Absorption of blood-clot and replacement of the same by celluloplastic exudate.
3. Conversion of the exudate into granulation tissue forming the provisional or ensheathing callus.
4. Ossification of this temporary callus, principally by cells from the bone-forming layer of the periosteum.
5. Absorption of new-formed bone from medulla and periosteum,

leaving only cortical layers united. Union by callus formation occurs a little more rapidly in children than in adults. The average length of time is as follows: (*a*) For the ribs, three weeks; (*b*) for the bones of the forearm, humerus, bones of leg, clavicle, four to five weeks; (*c*) for the femur, six to eight weeks.

Where fragments overlap, the ensheathing callus fills up all of the spaces left by the overlapping fragments, and forms the main bond of union (Fig. 51). The medullary cavity is seldom restored under these circumstances.

In comminuted or multiple fractures, as well as in those in which the fragments are widely separated, a large ensheathing callus forms. This gradually adapts itself to the amount of pressure upon it, following static principles. Small detached fragments are either absorbed or become encapsulated.

Fig. 53.—X-ray of Pseudarthrosis of Ulna Following Crushing Injury of the Entire Upper Extremity

Taken two years after the injury. Notice the well-marked lower epiphyses of the radius and ulna, and the silver wire *in situ* in the middle of the shaft of the humerus.

In simple fractures and in non-infected compound fractures, union occurs more rapidly than in any other forms.

In infected compound fractures the periosteal new formation of bone is greatly interfered with on account of the suppuration.

The formation of granulation tissue begins at the edge of the denuded bone and gradually the latter is covered. The various stages of repair described under simple fractures take place in infected compound fractures, but ossification proceeds very slowly—about twice as much time being required. In many cases necrosis of the denuded cortex occurs, greatly delaying the process of healing until the sequestrum of necrotic bone is removed.

In joint fractures, the effusion of blood into the joint cavity keeps the fragments apart. There is no tendency to callus formation on the joint side, owing to the absence of periosteum. Union occurs by ossification of the granulations which bridge the gap between the fragments, as well as by an ensheathing callus in the extra-articular portions of the bone.

The joint callus may interfere with its functions by projecting into it or by causing adhesions between the articulating surfaces, resulting in bony or fibrous ankylosis.

In epiphyseal separations union occurs by callus formation even where displacement is present through the medium of the periosteal bridge. Arrest of growth is rare, according to Poland, in comparison with the number of cases of epiphyseal separation.

Exuberant Callus.—In children and occasionally in adults the amount of callus formation is excessive. In superficial bones, like the clavicle, such an exuberant callus may simulate an overriding or other displacement of fragments. In those cases in which there is good apposition the excess of callus will gradually disappear. Where, however, there is considerable deformity, its absorption takes place very slowly and it adapts itself in form to static principles.

Fig. 54.—Skiagraph of Pseudarthrosis of Middle of Shaft of Humerus (G. G. Cottam).

In joint fractures the rôle which an excessive or exuberant callus may play has already been referred to.

In the intra-articular variety, *i. e.*, where the fracture is entirely within the joint, the callus formation is so small as not to interfere with the functions of the joint. In those joint fractures (true articular) where the line of fracture either extends into the joint from without or the reverse, the callus formation is often excessive and may interfere seriously with the functions of the joint, especially if there is much displacement.

Excessive callus formation in the shaft of the long bones may result in the inclusion of a nerve, such as the musculospiral (Fig. 50), in the callus.

It may also greatly interfere with the function of muscles and tendons.

Defective Formation of Callus (Pseudarthrosis).—The terms delayed union, fibrous union, failure of union, and pseudarthrosis are used so frequently in an erroneous manner that it is desirable to define them. We speak of delayed union when it does not occur within the usual period, but in eight to twelve weeks and in some instances even later. By fibrous union is meant that the fragments are held together by fibrous or connective tissue.

In the case of certain bones like the patella and olecranon process this is the normal mode of union in the majority of instances. It can only be considered as a pathologic condition when it takes place in bones in which osseous union is the rule and fibrous union, the exception.

While delay of union is a frequent occurrence, *a true failure of union is rare.* It occurs only when some definite bone disease exists, such as osteomalacia or sarcoma, or when there has been no attempt to fix the limb in a debilitated subject. The term pseudarthrosis should be applied to those cases in which a distinct false joint is formed at the seat of fracture (Fig. 54).

Fig. 55.—Pseudarthrosis Following Fracture of Neck of Femur (J. F. Binnie).

There are two groups of cases: (1) Where the fragments are united end to end or laterally by a more or less firm mass of connective tissue.

Various conditions are found: (*a*) There is close apposition of the fragments, but they are united by a short firm band of connective tissue. (*b*) There is considerable overlapping, the two fragments being held by interposed fibrous tissue. (*c*) The displaced end is soft or spongy. (*d*) It is enlarged and covered by a plate of bone or cartilage or is atrophic and pointed. To this group of fibrous union belong the majority of cases of delayed union and defective callus-formation.

(2) Pseudarthrosis or false joint formation. Only a few cases have been published which can be called genuine false joint formation. The ends of the fragments are covered either with bone or cartilage and more or less altered in shape, so as to form a shallow ball-and-socket joint, the capsule being represented by the surrounding fibrous tissue, and the synovial cavity by an adventitious bursa which results from the friction of the two ends.

The most frequent seats of ununited fractures are the middle of the shaft of the humerus, the upper and lower thirds of the femur, the patella, and olecranon.

The **causes** of delayed union, of fibrous union, and of pseudarthrosis are:

1. *Local Causes.*—(*a*) Imperfect immobilization of fragments. This is the most frequent of all causes and includes those cases in which there was insufficient fixation of the seat of fracture, too early use of limb, and too early employment of passive motion. In the cases of delayed union at the middle of the humerus or in the femur neglect to immobilize the elbow or knee respectively is the most frequent cause. (*b*) Great separation of fragments either through failure to reduce or as the result

Fig. 56.—Deformity (Overlapping and Lateral Displacement) after Fracture of Tibia.

Fig. 57.—Deformity Following Fracture of the Tibia and Fibula in Their Lower Third.
Note the double bony bridge uniting the two bones.

Fig. 58.—Deformity Following Fracture of the Tibia and Fibula in Their Lower Third.
Note the double bony bridge uniting the two bones.

of muscular action. (*c*) Interposition of bone, muscle, or of tendon between the fragments. (*d*) Poor blood-supply through injury to the nutrient artery, as in fracture of the neck of the femur where the head of the bone is only supplied with blood by a small artery in the ligamentum teres. (*e*) Tumors, such as a sarcoma developing in the callus or those cases in which the fracture was a pathologic one, the result of a neoplasm. The latter heal very slowly or do not unite at all. (*f*) Infection and excessive suppuration may delay union.

2. *General Causes.*—(*a*) Neuropathic causes, such as tabes, syringomyelia, or paralysis. (*b*) Constitutional conditions, such as the acute infectious diseases, scurvy, syphilis, osteomalacia, gout, rickets, rheumatism, chronic nephritis, diabetes, and alcoholism. Anemia resulting from prolonged lactation or long-continued fever also favors delayed or fibrous union.

The recognition, prevention, and treatment of delayed and fibrous union, etc., are considered on p. 137.

Faulty or Vicious Union.—This term is employed in those

Fig. 59.—Deformity (Rotary, Overlapping, and Angular) Following Fracture of the Middle of the Humerus.

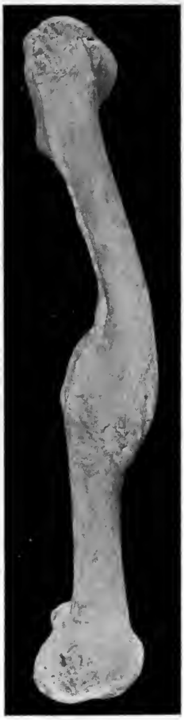


Fig. 60.—Deformity Following Fracture of the Femur (Angular and Lateral Displacement and Overriding).

Fig. 61.—Anterior View of Fig. 60 Showing Angular Deformity.

cases in which the deformity after union of the fragments is such as to cause not only a change in the appearance of the limb, but interference with its function either through shortening, stiffness of adjacent joints, or rotation of fragments.

It also includes cases of inclusion of nerves, tendons, or muscles in the callus.

The most frequent causes are lateral displacement with overriding, marked angular displacement, and axial rotation of fragments.

It is most apt to occur in the following bones:

1. Clavicle—Overriding or angular deformity.
2. Humerus—Surgical neck, middle of shaft, and supracondyloid region. Overriding or angular deformity.
3. Radius—Overriding with lateral displacement and rotation of fragments at lower end of bone.
4. Femur—Overriding with lateral displacement or angular deformity anywhere in shaft; also rotation of fragments.
5. Tibia and fibula—Overriding with angular displacement or rotation of fragments.

FIG. 62. — TRAUMATIC BOW-LEG AS A RESULT OF VICIOUS UNION FOLLOWING FRACTURE OF TIBIA AND FIBULA (Lovett).

THE TREATMENT OF FRACTURES.

GENERAL CONSIDERATIONS.

First Aid.—The treatment of a fracture may be said to begin from the moment of its occurrence. Much can be done for the comfort of the patient and correct union of the fracture by intelligent treatment during the first hours. The proper temporary fixation of the limb, the mode of transportation, and removal of the clothing all require special mention.

The use of first-aid dressings, *i. e.*, those which can be used until more permanent and suitable ones can be applied, varies, of course, with the individual bone. The following modes of such emergency treatment will be found useful:

(*a*) In fractures of the lower jaw the fragments can be temporarily and often permanently held in place by the use of a four-tailed bandage or the application of the Barton bandage.

(*b*) In fractures of the clavicle the use of the mitella or arm sling suffices as a first-aid dressing. It can be rapidly made by folding a piece of muslin one yard square in such a manner that the diagonally opposite corners are in apposition.

Instead of the mitella, the shoulder may be temporarily immobilized by the use of the Velpeau dressing.

(*c*) In fractures of the upper end and shaft of the humerus the mitella or sling can be temporarily employed or a splint of wood can be placed along the outer side of the arm, extending from the acromion process to the elbow, and the arm firmly held to the side of the chest by a bandage like the Velpeau, which supports the forearm and uses the thorax as a splint.

(*d*) In fractures of the elbow the arm can be temporarily placed in a sling, or two rectangular splints of heavy cardboard or thin wood can be applied along the posterior aspect of the arm, the elbow thus being held in a rectangular position for purposes of transportation, etc.

(*e*) In fractures of the forearm two splints of wood or heavy cardboard, well padded and a little wider than the forearm (Fig. 135), can be applied along the back and front respectively, extending from the elbow to the middle of the hand.

(*f*) Fractures of the metacarpal bones or phalanges are best temporarily cared for by placing them upon a well-padded anterior splint of wood extending from the middle of the forearm to the finger-tips.

(*g*) In fractures of the ribs or sternum the most convenient first-aid dressing is to make a few turns with a circular bandage of linen or muslin around the chest. The material used should be wide enough to extend from the axilla to the level of the umbilicus. It should be quite firmly applied and secured with safety-pins.

(*h*) In fractures of the upper and middle thirds of the femur a convenient first-aid dressing, even before removal of the clothing, is to take a board long enough to extend from the axilla to below the sole of the foot and, after padding it well, to apply it to the trunk and the outer

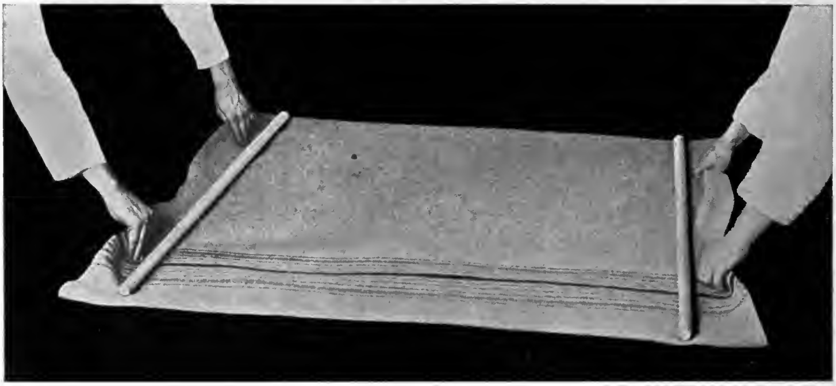


Fig. 63.—Use of Blanket Splint in Temporary Treatment of Fractures of One or Both Bones of the Leg.
Method of rolling blanket around broomsticks or similar pieces of wood (see text).

side of the broken limb by a number of turns of wide (four inch) muslin or linen.

During the application of this temporary long external splint moderate traction upon the foot, held as shown in Fig. 211, can be made by a bystander or an assistant. If such a long board is not obtainable, the blanket splint (Fig. 65) can be used, although it gives rather imperfect fixation of the upper third of the thigh.

In fractures of the lower third, where there is any tendency to displacement of fragments with resulting pressure upon the popliteal vessels (Fig. 176), the knee should be flexed and the limb placed upon a temporary double-inclined splint made of a piece of boxboard bent at its middle, or two short boards held at right angles to each other, and extending from the hip to the popliteal space, and from the latter to the heel respectively. These splints can be secured by circular turns of some bandage material.

(*i*) In fractures of the tibia, fibula, and foot, as well as in those of the lower half of the femur without tendency to displacement, the use of the blanket splint will be found of great aid. In the case of fractures of the leg or foot it can be left until a permanent dressing is used. Instead of a blanket a long pillow or soft cushion can be employed in the same manner.

The blanket splint can be rapidly made by folding a blanket in such

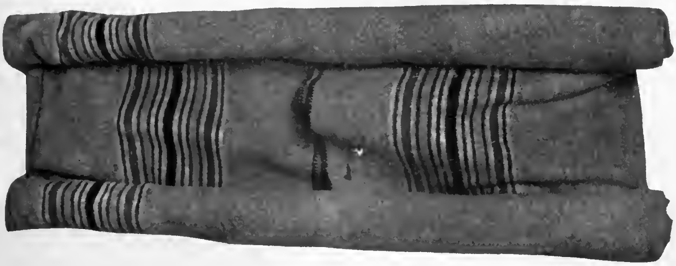


Fig. 64.—Blanket Splint Rolled up Ready for Use.
This illustration shows the blanket splint before it has been turned so as to receive the foot (see text)

a manner that it extends from the middle of the injured thigh to below the foot. Two pieces of narrow strong board or, better still, two broomsticks are rolled up in the blanket in the manner shown in Fig. 63. The rolled-up blanket is now turned in so that the board supports with

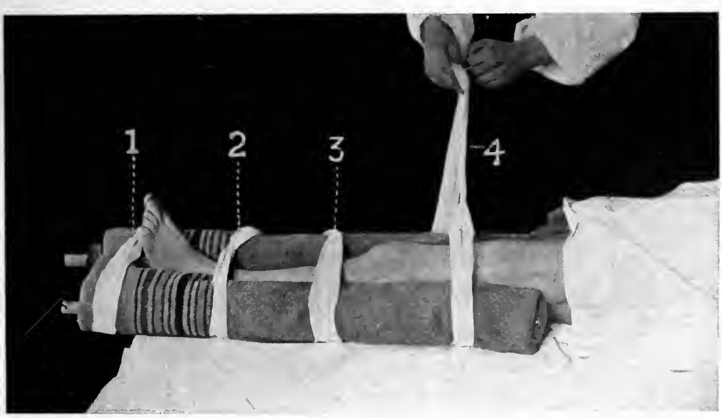


Fig. 65.—Method of Applying Blanket Splint for Temporary Treatment of Fractures of the Leg.
The leg is shown lying between the folds of the blanket splint, the latter being held together by strips of muslin bandage tied firmly together: 1, Below the foot; 2, just above the ankle; 3, below knee; 4, blanket.

their enveloping turns of blanket lie upon the posterior surface. Thus a trough is formed in which the limb is placed and firmly secured by loops of bandage, which are placed at the levels shown in Fig. 65.

Transportation of the Patient.—Patients suffering from a fracture of the ribs or pelvis should always be transported in a recumbent position, if possible, on account of the danger of visceral complications.

In fractures of the thigh or leg after the application of the emergency dressing the patient should be transported in a recumbent position, the support being as firm as possible, such as a wide board, shutter, wooden rail, etc. If these are not at hand, and, in general, it may be said, in the transfer of such a patient, the persons transporting them should be distributed in the manner shown in Fig. 66, viz., one supporting the head and shoulders, a second the pelvis, and a third the two limbs.

Removal of Clothing and Examination of Injured Part.—This should be done in as systematic and intelligent a manner as possible.

The clothing should be removed, if possible, from the upper part of the body first. The sleeves of a coat, shirt, or lady's waist can either

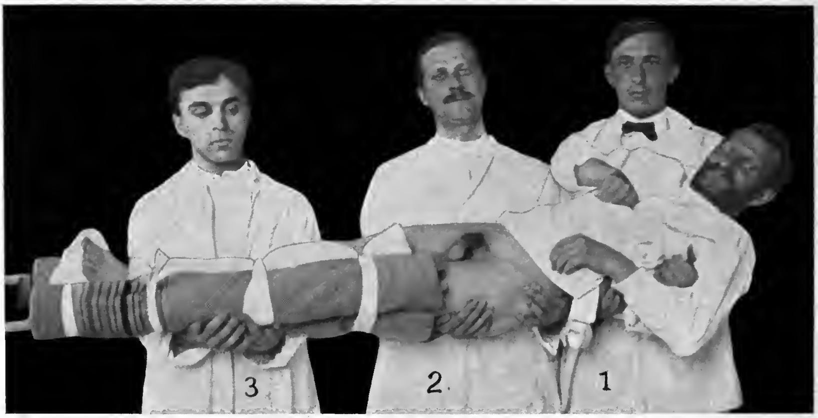


Fig. 66.—Method of Transporting Patient Suffering from Fracture of One or Both Bones of the Leg.

The limb has been inclosed and immobilized in a blanket splint; assistant No. 1 grasps the head and shoulders; assistant No. 2, the pelvis; assistant No. 3, the injured and sound legs.

be cut along the seams or the entire coat or waist slipped off, beginning with the non-injured side.

The trousers or skirt can be best removed when the pelvis is raised and supported by one assistant, while another pulls these articles of clothing off. Should this be impossible, it is best to cut them off.

The first examination should not only be made for the purpose of making a temporary diagnosis of the existence of a fracture, but also of the presence of complications.

The manipulation of the injured part when the patient is first seen should be carried out in as gentle a manner as possible.

Careless or rough handling of a fracture will often convert an impacted into a non-impacted, or a simple into a compound, one. The examination at the site where the injury occurred is seldom satisfactory, and, after having made a diagnosis of a fracture and its location, further manipulation is best deferred until the patient can be systematically and thoroughly examined and the appropriate treatment instituted.

The method of making such a diagnosis has been fully discussed on p. 90.

Reduction.—The reduction of a fracture is the effort made by the surgeon to overcome any tendency to displacement and thus to place the fragments in such close apposition that an accurate and firm union is possible.

The best time in general for the reduction of a fracture is as soon as possible after the accident, if the patient's general condition will permit it.

If there is marked displacement of fragments, so that there is danger of necrosis of the overlying skin or of damage to the adjacent vessels or nerves, an early reduction is imperative.

In all cases in which reduction is very painful or difficult, whether performed shortly after the accident or at a later period, it is best to administer an anesthetic to overcome muscular contraction and to decrease the amount of pain.

In a case of fracture in which the above-mentioned indications for immediate reduction do not exist, the reduction may be postponed to a later period, *e. g.*, at the end of a week, when the greater portion of the swelling has disappeared. At such a time, and especially in fractures of the leg, it is advisable to administer an anesthetic.

In incomplete fractures reduction is sometimes indicated at the time of fracture in order to convert the fracture into a complete one (Fig. 137).

The special obstacles to reduction are: (*a*) Interlocking of fragments (*b*) interposition of bone or soft parts; (*c*) fixation of one fragment in the fascia or in the skin; (*d*) a dislocation complicating a fracture (Fig. 290); (*e*) impaction of fragments.

An incision in order to effect reduction is justifiable if the surroundings are such that perfect asepsis may be obtained, and it is impossible, even under anesthesia, to reduce the fracture, especially if—(*a*) there is danger of ankylosis through the displacement of a fragment in close proximity to a joint; (*b*) if there is danger of necrosis of the skin or of injury of a vessel or a nerve; or if it is impossible to reduce it on account of an accompanying dislocation. The same may be said of incision as was said of reduction, viz., that if it is not performed within a few hours after the injury, it would be best to postpone it until the swelling has decreased—say after seven to ten days.

The manipulations necessary to effect reduction vary with the variety of displacement, as determined by inspection, palpation, skiagraphs, etc.

(*a*) For overlapping of fragments traction upon the limb below the point of fracture and counterextension suffice.

(*b*) For lateral displacement a combination of traction, counterextension, and direct pressure upon the fragments through the unbroken skin is advisable.

(*c*) If there is rotary displacement, the manipulations consist in twisting the bone upon its axis in such a manner as to correct any tendency of the limb to roll inward or outward.

(*d*) In the greenstick fractures of children the angular deformity can be corrected by placing the thumbs against the angle while the fingers grasp the limb above and below it (Fig. 137).

In many cases of fracture the chief obstacle to reduction is muscular spasm, and this is often best overcome by the application of extension to the limb.

In cases where the overlying muscle or fascia have been penetrated by the sharp end of one of the fragments the latter can be reduced by flexing the joints above and below the point of fracture. If this fails, incision is indicated.

In impacted fractures reduction is contra-indicated unless marked deformity exists.

The Use of Splints, etc.—After reduction of a fracture retentive apparatus is indicated in order to maintain apposition. In the use of dressings we distinguish between those which are temporary and those which are permanent. The former are employed where the swelling of the limb is such that some dressing can be employed which will not cause pressure.

Certain general principles should be followed in the use of splints.

(*a*) A splint, after being applied, should not interfere with the circulation, allowance always being made for the swelling of the limb, which almost invariably occurs during the first week.

(*b*) The splint, if flat, should be wide enough not to permit pressure to be made upon the point of fracture, *i. e.*, it should project a little beyond the limb.

(*c*) In general it is best to immobilize the adjacent joints above and below the seat of fracture, but no dressing should be permitted to remain so long as to produce stiffness of the joints and muscular atrophy.

(*d*) The skin, even in simple fractures, must be cleansed with green soap, water, and alcohol. If blebs or an area of threatening necrosis of the skin exist, they should be freely dusted with powdered boric acid and a few layers of aseptic gauze applied.

Various Forms of Dressings.—The form of retentive apparatus to be employed will vary, of course, with the individual bone.

The various methods of treatment of fractures in general will be chiefly described here. The surgeon who is called upon to treat fractures should be already provided with the majority of the apparatus enumerated. This is a better plan than to be obliged to hastily gather the material together at the time it is needed. Every well-equipped hospital should possess a separate room to serve as a storehouse for the special forms of apparatus for fractures and for materials such as wood, tin, wire, etc., for the manufacture of splints. It should always be supplied with an ample stock of plaster-of-Paris bandages. The detailed instructions as to the application of these splints and other forms of retention apparatus are given under the individual forms of fracture.

The most important articles of a "fracture equipment" are the following:

1. Plaster-of-Paris bandages for making molded splints and circular casts (p. 117).
2. A stock of basswood, $\frac{3}{16}$ of an inch thick, for making wooden splints (p. 120).
3. An assortment of metal splints (p. 122) or materials for making them.
4. Muslin for bandages and slings.
5. Five-yard rolls of ordinary and zinc oxid adhesive plaster three inches wide.
6. Cotton batting and sheet wadding for padding splints (p. 119).
7. Strips of tin or thin cypress for strengthening plaster casts (p. 122).
8. Special apparatus for fractures of the nose or the jaw (pp. 143, 152).
9. Dental rubber for use in compound fracture casts (p. 120).

The selection of a dressing for the immobilization of a fracture depends upon a number of factors. These are:

(*a*) The particular bone involved and whether apposition can be maintained with or without extension.

(*b*) Whether great swelling be present or not.

(*c*) Whether the fracture be simple or compound.

(*d*) Whether ambulatory treatment be preferable to that in the recumbent position. This latter question applies, of course, only to fractures of the lower extremity.

The following forms of retentive apparatus are most often used.

Plaster-of-Paris Bandages.—No material is more frequently employed in the treatment of fractures. One can either purchase the plaster-of-Paris bandages as put up by various surgical dressing manufacturers in sealed metal cans or the bandages can be cheaply made. The best average widths are two, three, and four inches respectively. If the bandages are to be made by the surgeon or his assistants, it is advisable to get the kind known as dental plaster, which is sold in five-pound cans. If many bandages are made at one time, they can be kept in a tin bread-box. The proper amount of plaster to put into a bandage can only be learned by experience. The best material upon which to spread the plaster is crinoline, cut into four-yard lengths and stitched together. The ordinary commercial crinoline is so stiff that it should be washed in lukewarm water, thoroughly rinsed, and dried. Ordinary cheese-cloth can be used instead of crinoline, being cut along a line at which a thread has been pulled out.

In using the bandages it is best to soak them in lukewarm water without the addition of salt or alum. Each bandage should remain in the water until all air-bubbles cease to appear, and it is then ready to use. The water in which the bandages are immersed should be renewed after every third bandage.

Plaster-of-Paris bandages are employed in making the following forms of dressings: (*a*) Molded plaster splints; (*b*) circular plaster casts, which are to be used as permanent dressings and not to be removed until union is complete; (*c*) removable plaster casts.

Molded plaster splints are used for the treatment of fractures of the humerus, elbow-joint, and forearm in the upper extremity, and for those of the shaft of the femur and for the tibia and fibula in the lower extremity. They are best made by first wrapping strips of wadding around the parts to be covered by the splints.

There are two methods of making the splint. The first and the preferable one is shown in Fig. 67. An ordinary newspaper is laid upon the limb and a pattern cut which corresponds to the dimensions which the plaster splint should have. This paper pattern is then laid upon a table and the plaster bandage unrolled back and forth over the entire area of the paper pattern. In this manner it is possible to obtain a splint of uniform thickness. Usually about ten to twelve layers of the bandage are necessary. After the splint has thus been laid out, so to speak, upon the paper pattern, the entire plaster splint is then applied to the injured part and molded to the latter. Before the application of the molded splint the fractured limb is first covered by two or three thicknesses of sheet wadding or a flannel bandage.

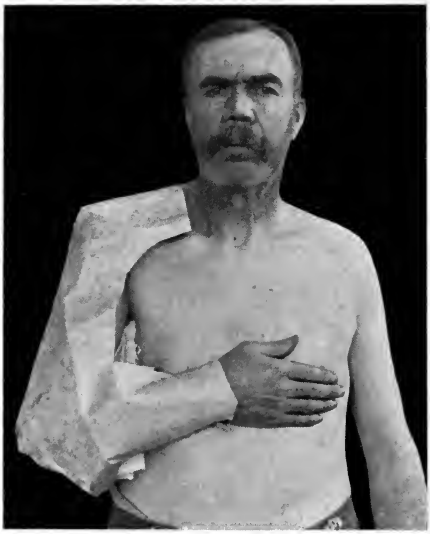


Fig. 67.—Paper Pattern to be Used in Making Molded Splint for Fractures of the Upper End of Shaft of Humerus.

The second method is to apply plaster-of-Paris bandages to the injured part directly, running it back and forth along the entire area to be covered (Fig. 68) until a sufficient number of layers have been applied to make a firm but light cast. From eight to fifteen layers are usually necessary.

Dry plaster can be rubbed over the surface before drying occurs, or a thick cream can be made by mixing some plaster with a small quantity of water.

Two assistants are usually required, one of whom supports the limb and keeps the fragments in apposition, while a second molds the rapidly hardening cast to the limb by gentle pressure. In the absence of a second assistant this can be done by the surgeon. Molded splints and circular plaster casts can be made much lighter by employing one of several devices. Thin strips of tin which has been perforated in many places or strips of cypress as is used for making strawberry boxes or fruit-baskets can be incorporated into the splint or cast. Another method is to use very few thicknesses of plaster bandages, covering them when the cast is dry with several layers of a bandage made of crinoline soaked in a solution of gluten flour.

Circular plaster casts should not, as a rule, be used as a primary dressing on account of the danger of gangrene from pressure upon the rapidly increasing swelling which occurs in the first week. A circular cast can be made so that it can be removed or opened so as to allow for swelling by inserting a strip of tin along one side between the skin and cast, and then cutting through the latter along the line where the tin has been placed, immediately after application of the cast.

The mode of application of a circular removable or non-removable cast is as follows: The limb is covered by several layers of sheet-wadding which is obtained in sheets and torn into strips from three to five inches wide and rolled into roller bandages. Such sheet-wadding can be purchased at any dry-goods store. Particular care should be taken to place it quite thickly over bony prominences near the joints and pelvis.

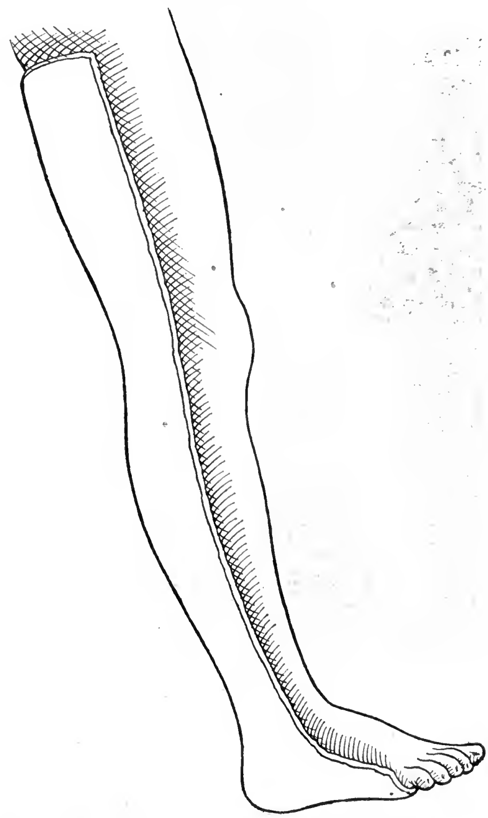


Fig. 68.—Molded Posterior Splint Used in Fractures of the Leg.

A circular cast should always extend well above and below the point of fracture, and in the lower extremity the joints above and below should be immobilized. The first roller is applied one layer thick as far up and down the limb as it will reach, and in the use of the other bandages care should be taken to have all parts of the cast of equal thickness.

A plaster bandage should never be reversed on account of the subsequent contraction when thus applied. The weight of the cast may be greatly reduced by the use of tin or thin wood strips or of gluten, as suggested above. The details of the use of both molded plaster splints and of casts in general will be referred to under the individual forms of fractures.

A plaster cast can be best removed by moistening it along a straight line with frequent applications of cloths soaked in hot water or vinegar and then cutting through the cast with a stout short-bladed knife. After it has been cut to the level of the sheet-wadding, the edges of the cast can be separated and the wadding cut to the skin.

For certain fractures, such as those of the thigh, or in the treatment of compound fractures strips of carriage iron $\frac{1}{8}$ to $\frac{3}{16}$ inch in thickness can be incorporated into the cast.

If one wishes to keep the seat of fracture exposed, as in a compound fracture, an opening can be made in the cast before it is dry. If the fenestra are so large as to weaken the cast, the latter can be strengthened by the use of iron strips, as shown in Fig. 69.

The edges of the openings or fenestra in such a cast can be best protected by the use of dental rubber (Fig. 70), as suggested by Crouse.[8] This permits the frequent irrigation of compound fractures to be carried out without softening the cast.

Fig. 69.—Method of Treating Compound Fracture (Infected), Involving the Knee-joint.

The thigh and leg are inclosed in a plaster cast, the two casts being connected by means of U-shaped pieces of iron, which are incorporated into the plaster.

Dental rubber, known as No. 2, is dissolved in commercial chloroform, sufficient of the latter being used to form a semigelatinous paste. Absorbent wool is worked into this until a meshed mass results.

Strands of the latter are then packed between the previously shaved, sterilized, and well-dried skin and the cast, around the entire circumference of the fenestrum or opening in the cast.

By using a plain chloroform solution of the rubber the entire area is rapidly veneered until a smooth rubber mass exists. The cast is then covered with shellac.

Wooden Splints.—Every surgeon or general practitioner who is called upon to treat fractures should be provided with a stock of wooden splints. The best material for the smaller ones for the upper extremity is basswood $\frac{3}{16}$ of an inch thick. For the larger splints, such as the double-inclined plane or long external splints, pine or some similar wood is used.

The following varieties are suggested:

A. Splints for use in treating fractures of one or both bones of the forearm. A stock of these should be kept on hand, suitable for both children and adults. These should include—(*a*) Splints extending from the axilla to the wrist for use in fractures of the olecranon; (*b*) splints extending on the extensor surface of the forearm, from the external condyle of the humerus to the middle of the back of the hand, and similar ones extending from just below the bend of the elbow to the middle of the palm of the hand. All these should be a little wider than the arm or forearm, and should be well padded with ordinary cotton batting before being used (Figs. 128, 134, 136).

B. Posterior splints for leg. These should extend from the level of the trochanter to below the heel for use in fractures of the patella.

C. Splints extending from the middle of the thigh to below the heel for use in the application of a blanket or a pillow splint.

D. The following special splints should also be ready for use:

(*a*) A long external splint (Fig. 167) for use in fractures of the femur.

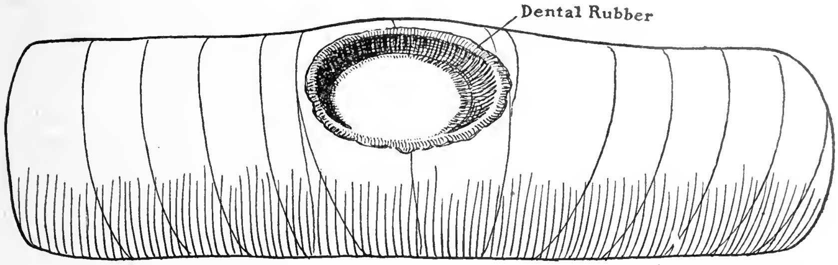


FIG. 70.—USE OF DENTAL RUBBER ACCORDING TO CROUSE IN FENESTRATED CAST FOR COMPOUND FRACTURES.

(*b*) A double-inclined plane (Fig. 181) for use in fractures of the lower end of the femur.

(*c*) Volkmann's sliding splint for use with Buck's extension in fractures of the femur.

(*d*) A fracture-box (Fig. 206).

(*e*) A wooden Mitteldorpf triangle (Fig. 111).

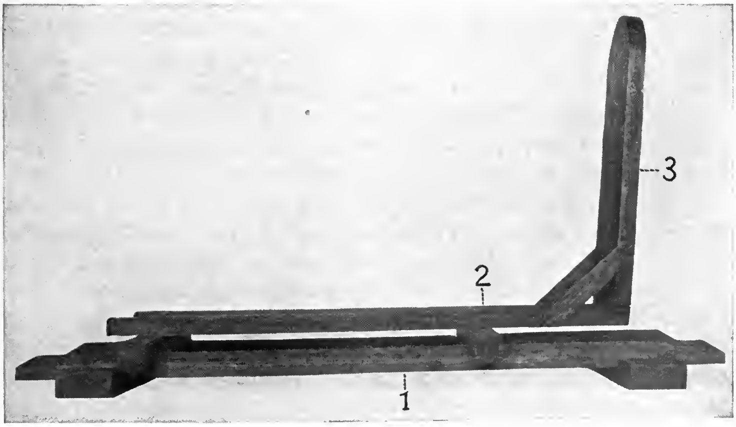


FIG. 71.—SIDE VIEW OF VOLKMANN SLIDING SPLINT FOR TREATMENT OF FRACTURE OF THE FEMUR. 1, Support which rests upon the bed; 2, base-board on which foot itself rests; 3, foot-piece.

The dimensions and other details in regard to their construction will be referred to later.

Instead of wooden splints for use in the upper extremity, other materials can be employed, such as heavy cardboard, yucca-fiber, or felt. Wood is preferable to all of these except in young children, where heavy cardboard is best.

The best method of holding splints for the upper extremity in place is by encircling the part at intervals with two-inch wide strips of adhesive plaster (Fig. 128) and applying a bandage over this and the splints. A roller bandage should never be applied directly next to the skin unless one wishes to hold a dressing in place.

Metal Splints.—These are quite extensively employed as both temporary and permanent splints. For the upper extremity they can either be made of tin or wire netting when needed. It is better, however, to keep an assortment of perforated metal splints known as the Levis. These are sold in two sizes, for adults and children. The most useful of these are the rectangular or acute-angled external splints, for use in fractures near the elbow-joint, and the adjustable anterior splint, for similar fractures. Other useful metal splints are the Volkmann metallic gutter, the Hodgen splint, the Cabot posterior splint, and the Smith anterior splint. These will be described in connection with fractures of the thigh and leg.

The Use of Extension.—This is so frequently employed in the treatment of fractures that it requires special mention. The object of traction is to overcome the tendency of muscular action to cause longitudinal displacement of fragments. It is most often used for this purpose in fractures of the femur, but Bardenheuer[9, 10, 11] has suggested its more general application in fractures of the humerus or tibia. He believes that extension overcomes displacement better than operation or ordinary fixation dressings, and has employed it in 10,000 cases, especially those in close proximity to joints combined with early passive movements. He has never seen a case of exuberant callus or of delay in union.

Few surgeons have followed the suggestions of Bardenheuer as to the use of extension in fractures of the humerus or tibia, the majority believing that it is possible to secure and maintain good apposition without its use. Traction by the use of adhesive plaster applied to the limb and connected with a weight and pulley is chiefly employed at the present time in connection with fractures of the femur, and will be described later (p. 245). Its usefulness in overcoming displacement in fractures of the humerus should not be forgotten, and it can frequently be combined with the use of a Mitteldorpf triangle (page 180).

Ambulatory Treatment of Fractures.—In 1891 F. Krause[12] recommended a method of treatment of fractures of the bones of the leg which would permit the patient to walk upon the injured limb as soon as a cast can be applied to it. The method was soon used in the treatment of fractures of the femur, with the aid of especially constructed splints or of plaster casts.

The advantages of the method are: (*a*) Elderly or feeble persons are much less liable to attacks of hypostatic pneumonia or bronchitis; (*b*) delirium tremens is less likely to develop; (*c*) there is little tendency to muscular atrophy or joint stiffness; (*d*) the formation of callus is usually quite abundant; (*e*) the period of time before the injured person is able to return to work is much shorter; (*f*) decubitus does not occur.

The ambulatory method of treatment has never been extensively used, owing to the fact that there are a number of disadvantages in its use. These are the danger of recurrence of deformity even after perfect reduction of the fragments has been accomplished, and the period of disability is not much less than is the case with the older methods of treatment. In fractures of the thigh especially, it is very difficult to maintain efficient extension.

In general it may be said that the ambulatory method should not be employed in fractures of the femur unless it is absolutely necessary to avoid the recumbent position in elderly or feeble individuals. Even under these circumstances it is best to avoid its use unless the patient can be seen frequently and the position of the fragments controlled from time to time. The method has far greater advantages in fractures of the femur than in those of the leg. It should never be employed until all the primary swelling has disappeared, *i. e.*, after four to five days.

The special forms of apparatus will be described in the sections upon Fractures of the Femur (p. 234).

One point is to be mentioned especially in connection with ambulatory treatment of fractures of one or both bones of the leg, namely, that there is great danger of a condition of traumatic flat-foot resulting from the patient stepping upon the foot within a few days after the fracture has occurred.

Another objection is that casts for fractures of the leg are difficult to apply, since a cast which will fit a patient during the first week will become too loose after this time and not give proper support to the point of the fracture.

Operative Treatment of Simple Fractures.—The opinions of surgeons are so divided in regard to this question that it is necessary to give a brief résumé of the subject. For many years the operative treatment of simple fractures of the patella has been practised. Gradually this effort to secure not only bony union, but accurate approximation of fragments, was extended to fractures of the olecranon process. Since the development of a more perfect technic the field has been so enlarged as to include every one of the long bones of the body in which reduction is either difficult or impossible, or in which the fragments cannot be kept in position by the ordinary methods.

The more systematic and extensive use of the *x*-ray has undoubtedly played an important part in the development of the tendency to operate upon simple fractures. In this connection it is well to call attention to a rather frequent experience of those who have occasion to treat a large number of fractures which have been subjected to *x*-ray examination. The skiagraph will often show a marked displacement of a fragment—so great, in fact, that one would expect much visible and palpable deformity.

In many of these cases, however, the examination of the injured parts by the ordinary methods, such as inspection, palpation, or measurement of parts, reveals but little deformity. In some cases this discrepancy is due to a faulty position of the tube in taking the *x*-ray.

In the majority, however, such faulty technic is not the case. It is well to bear this exaggeration of deformity in mind in connection with the suggestion of some surgeons to operate upon all simple fractures in which the x-ray shows marked displacement of fragments.

Some surgeons, like Lane, Fritz Koenig, and others, advise operative interference in every case of simple fracture in which there is considerable displacement of fragments or difficulty in maintaining them in apposition. There are other surgeons, like von Eiselsberg, Körte, and others, who would restrict the operation to fractures of the patella. It would seem as though the safest position at the present time is the middle one. It would be folly to teach that every simple fracture which is difficult to reduce or to secure ideal reposition in, was an indication for operation. Such views would be productive of the greatest possible harm for the following reasons:

An operation for the reduction of a simple fracture, followed in the majority of cases by suture of the fragments, is a step which should only be undertaken if the facilities for an aseptic technic are perfect. Such conditions can be best secured in hospitals, and an attempt to perform such operations without the proper precautions means infection, which, although it may not be fatal, will jeopardize the usefulness of the limb. In experienced hands and with aseptic surroundings the danger of infection is no greater than would be the case in an interval appendectomy.

The indications for the operative treatment of a recent simple fracture are, in general: (*a*) If reduction cannot be completely made; (*b*) if correct apposition cannot be maintained; (*c*) if there is interposition of bone or soft parts; (*d*) if the fracture is a spiral one, with considerable displacement of fragments; (*e*) if fragments are rotated upon each other; and (*f*) in multiple fractures.

The special indications are that it is seldom required in fractures of the clavicle unless pressure upon blood-vessels or nerves exists. In fractures of the humerus operative interference may be required in fractures at the upper end, when complicated by a dislocation of the head of the humerus. For the fractures of the remainder of this bone, operation is not indicated unless there is evidence of involvement of the musculospiral nerve. In fractures of the femur there is a difference of opinion. Some advocate uniting the majority of recent fractures of the neck either by the use of a metal suture or some device, such as screws or ivory pegs. This view has received but little support. Fritz Koenig,[13] in a recent article, warmly urges suture in cases of fracture at the junction of the head and neck of the femur. In fractures of the shaft of the femur operation is indicated if good apposition cannot be secured by the use of extension.

Operative treatment has been more frequently employed in connection with fractures of the bones of the leg than in any other part of the body, and is indicated if reduction is impossible or the deformity is very marked.

The indications for operation in fractures of the patella, olecranon, and os calcis will be taken up under the respective headings.

In fractures in close proximity to joints in adults, as well as in epiphyseal separations with considerable displacement, the question of operative reduction and suture will arise.

Displacement of fragments, especially in the elbow-joint, is apt to be followed by serious interference with the function of the joint. If the surgeon believes that the latter danger menaces the patient, it would be better to cut down upon the fracture and replace it, uniting it or not to the adjacent bone as the individual case requires. The technic in such articular fractures is very difficult, and operations should not be undertaken without considerable experience.

The advantages of an operative reduction of a recent simple fracture are that—(*a*) Anatomically accurate apposition can be secured, and, if necessary, maintained, by proper fixation apparatus (see below); (*b*) pressure on nerves or blood-vessels can be relieved; (*c*) interposed parts, like fragments of bone, muscle, periosteum, can be removed; (*d*) in fracture close to joints there is less danger of ankylosis; (*e*) in fractures like those of the patella, olecranon, and os calcis, a firmer union can be secured. Another advantage to be especially mentioned is that the patient is able to resume his occupation at an earlier date than would be the case in fractures with badly displaced fragments.

The arguments used against operative treatment are: (*a*) That an anatomically perfect or ideal reposition is not essential to good function of the limb; (*b*) the use of wire often causes rarefaction of the bone and may be a cause of non-union; (*c*) the anesthesia must necessarily be longer than is the case in a simple non-operative reduction; (*d*) the fragments are often found so badly splintered that a number must be removed, or the ends of the bone are so irregular that suture or even reduction alone is impossible without resecting the ends of the bone; (*e*) the danger of infection is a contraindication to its use except in the hands of those with considerable experience and equipped with a perfect aseptic technic; (*f*) equally good results can be obtained, in the majority of simple fractures with marked displacement, if an anesthetic be given to reduce the fracture and sufficient extension be maintained after its reduction. Bardenheuer, after an experience of 10,000 cases treated by extension alone, believes that an indication for operative reduction and suture is present only in rare instances.

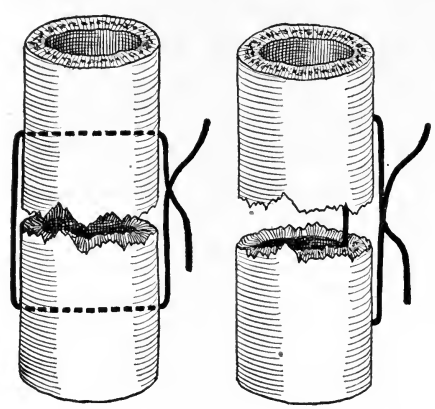
Best Time to Operate.—The general consensus of opinion is that the most favorable time to operate in recent simple fracture is at the end of the first or beginning of the second week. At this time the process of callus-formation is most active. The blood-clots and loose shreds of tissue have begun to be absorbed, so that the fragments are more easily accessible. In cases of fracture of the patella or olecranon the operation can be undertaken as early as the second or third day.

No attempt should be made to remove the clots or shreds of tissue if they are present, because they aid in the formation of the callus by acting as irritants.

Methods of Fixation of the Fragments.—In the majority of cases the reposition of the fragments alone is not sufficient to maintain accurate apposition. It is usually necessary to employ some means of mechanic fixation.

In all the methods to be described the preparation of the parts is the same as for any aseptic operation (see Vol. V). The opportunity for serious complications resulting from septic infection is greater than in any other class of operations. It is for this reason that extraordinary caution must be exercised. The incision should be large enough to expose the seat of fracture thoroughly. The materials used to secure fixation are: (1) absorbable sutures, such as chromicized catgut or kangaroo tendon; (2) metal suture of silver or bronze aluminum wire; (3) screws, nails, clamps, etc.

1. *Absorbable Suture Material.*—These are very frequently employed at the present time, especially in uniting fractures in which there is but little tension. As examples of this class may be mentioned fractures of the clavicle, olecranon, patella, tuberosity of the os calcis, and for separation of processes, such as the epicondyles of the humerus. The best material for this purpose is kangaroo tendon.



A B

Fig. 72.—Two Methods of Suturing Bone for Fractures.

A, A less desirable method (the wire passes through the entire thickness of the bone, and back again to the starting-point); B, the preferable method, the wire simply passing through the cortex on one side of the bone and out again.

2. *Metal Sutures.*—Wherever there is likely to be any tension upon the sutured fragments, it is best to employ wire. One can use either a moderately heavy silver wire or two threads of a very fine size of the silver wire twisted together or bronze aluminum wire.

The great objection to silver wire is that it is very apt to break while the knot is being twisted. Bronze aluminum wire has far greater tensile strength and can be warmly recommended as a substitute for silver wire.

The methods of using absorbable or non-absorbable (wire) sutures vary with the condition of the fragments and the custom of the individual operator. Three excellent methods for use in the long bones are: (*a*) To drill openings only through the cortex (Fig. 72, B) of each fragment and, after approximating the latter, to tie or twist the suture; (*b*) the second method is to surround the entire circumference of bone with the suture and thus hold the fragments together without drilling the bone; (*c*) the suture simply traverses the periosteum. The first and second methods can be used for the long bones. The third method, of including the periosteum only, is applicable only to the patella and olecranon (see p. 256).

3. *Mechanic Devices.*—This includes the use of screws and is only applicable to oblique or spiral fractures and to those of the neck of the femur (Fig. 74). Arbuthnot Lane recommends steel pins and staples. Others have employed ivory pegs which are driven through the two fragments or are inserted into the shafts. Another device is the Parkhill clamp. The objection to all these mechanic devices is that they act as foreign bodies. It is difficult to keep the tract in which they lie aseptic, rendering it necessary in many instances to remove the pin or peg. The latter statement also applies to many cases in which metal sutures are used.

To sum up, the operative treatment of simple fractures is indicated in fractures of the patella in which there is an extensive tear of the apo-

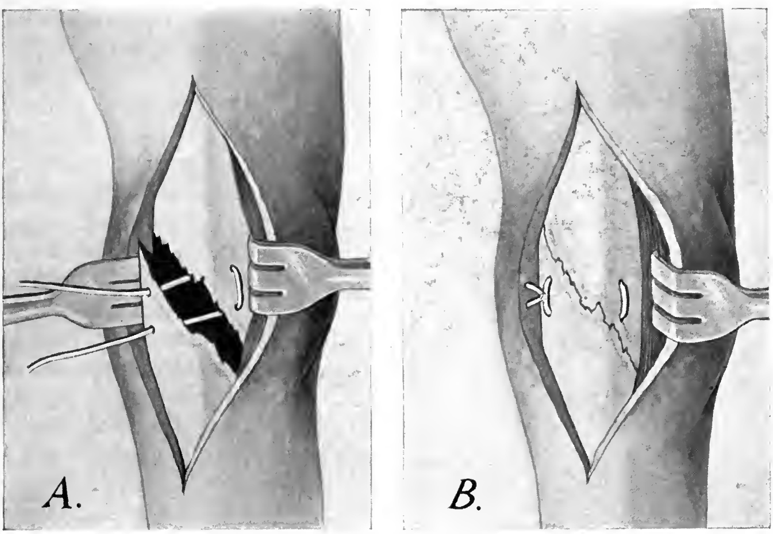


Fig. 73.—Mode of Wiring in Oblique Fracture of Long Bone.
A, Shows method of insertion of the silver or bronze aluminum wire; *B*, shows fragments in apposition with wire suture tied.

neurosis (p. 255), in fractures of the tuberosity of the os calcis and of the olecranon process. It is only necessary in other fractures when there is marked dislocation and inability to effect reduction, or when there is pressure on vessels or nerves. The ideal method of fixation is by an absorbable suture, like catgut or kangaroo tendon, without drilling the bone. This is not applicable to fractures in which there is great tension. In the latter metal (bronze aluminum) wire is to be preferred to nails, pins, etc.

Recognition, Prevention, and Treatment of Complications.—
Disturbances of the Skin.—The most frequent complication on the part of the skin in simple fracture is the extensive ecchymosis. These are often, especially in fractures of the bones of the leg, accompanied by blebs containing either clear or blood-stained serum. In order to

prevent a possible infection it is best, in every case of simple fracture, to wash the skin with green soap and water. If the parts are badly contused and very hairy, they should be shaved. If many blebs are present, they are dusted with powdered boric acid or Thiersch powder (1 part of salicylic acid to 16 parts of powdered boric acid) and then covered with sterilized gauze. If a fragment impinges upon the skin so as to threaten the vitality of the latter, the skin over it should be thoroughly cleansed and the fragment released by incision. The care which should be exercised in using plenty of padding over bony points in the application of splints has been referred to. Especial attention is again called to the danger of gangrene of the skin resulting from the application of too tight a circular cast or bandage while considerable swelling of the soft parts is present.

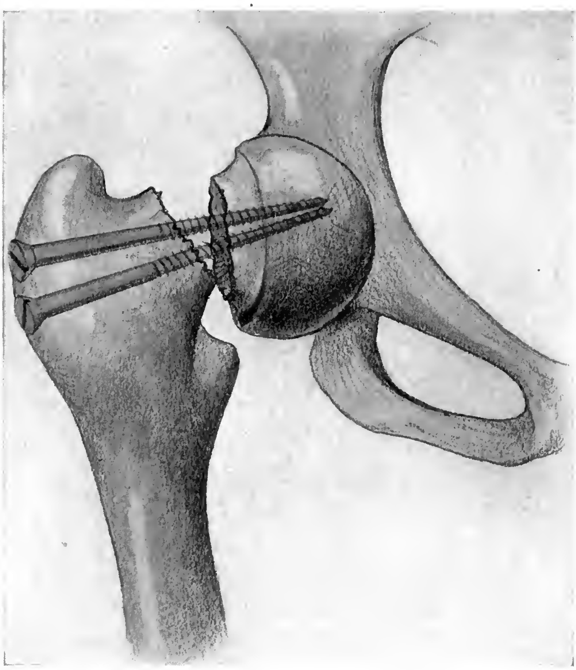


Fig. 74.—Method of Uniting Fractures of the Neck of the Femur by Means of Screws (after Keen).

Thrombosis and Embolism.—It is impossible to prevent this complication. The presence of thrombosis can be recognized by the excessive edema of the limb and the distention of the superficial veins. If these are absent, the condition is not recognized until the symptoms of pulmonary embolism suddenly appear (p. 99). The condition is one which cannot be prevented. The possibility of its presence must always be borne in mind in ill-nourished or aged persons. If the phlebitis has been recognized, the limb should be elevated, the patient kept absolutely quiet, and a 10 per cent. ichthyol ointment or wet dressing employed.

Injuries to Arteries and Veins.—The symptoms of an injury to an artery or vein have been enumerated on p. 100.

The prophylaxis lies in the avoidance of rough manipulation of fragments in fractures which lie in close proximity to the larger vessels. A thorough knowledge is also essential of the possibility of a displaced fragment compressing or lacerating an artery or vein if not properly reduced and maintained in position. Such injury is most likely to follow a supracondyloid fracture of the femur, and requires treatment with the double-inclined plane.

If an injury to an artery or vein is such that gangrene of the limb is threatened, immediate amputation well above the point of fracture should be performed.

Injuries to Nerves.—The symptoms of injury of a nerve may be present immediately after the injury if it has been contused or torn by a fragment, or the symptoms may appear during the latter part of the period of healing as the result of the pressure of or inclusion in the callus. The recognition of this complication is not difficult, and the diagnosis has been described (p. 101). It is impossible to prevent either the early or late form of nerve injury.

The treatment will vary with the diagnosis. If the nerve has been contused at the time of injury, it is best to wait and apply heat to the parts and use electricity as soon as the splint can be dispensed with. If the nerve has been lacerated, immediate suture should be performed. In those cases in which the nerve is compressed or caught within a callus the removal of the excessive callus or displaced fragment is indicated.

Fat Embolism.—This occurs more frequently after simple fracture than compound. The recognition of this condition has been previously referred to (p. 102). The prophylaxis will consist in careful handling of the limb and every effort to secure accurate approximation and fixation.

There is no special treatment for this condition.

Delirium Tremens and Traumatic Delirium.—The recognition of both of these complications has been fully taken up on p. 103.

As prophylactic measures, one should give large doses of alcoholic beverages to those who have been heavy drinkers. At the same time it is advisable to give seaatives, like the bromids and chloral, or hypnotics, like sulphonal, trional, or veronal, in order to prevent this disagreeable and not rarely fatal complication. When the symptoms have appeared, large doses of sedatives should be given. The same principles serve in the treatment of traumatic delirium.

Shock and Hemorrhage.—Shock is more frequently a complication of fractures of the thorax and pelvis than of the bones of the extremities. Too much emphasis cannot be laid upon the fact that if a considerable degree of shock is present in a case of fracture of the ribs or of the pelvis one should look for visceral complications.

Among the latter may be mentioned contusion or concussion of the heart, wounds of the lung, hemothorax and pneumothorax, and ruptures of one or more of the abdominal viscera.

It will be unnecessary to take up the symptoms and treatment of either shock or hemorrhage here, since they are fully dealt with in Volume I. One point needs, however, to be mentioned, and that is, should the symptoms either of shock or of hemorrhage be present in a case of simple fracture, one should always search for evidences of visceral complications. If the signs of primary shock following a fracture do not disappear within a few hours, a thorough examination of the patient will often reveal some cause for its continuance, in such a visceral injury.

The avoidance of shock in simple fractures is best accomplished by restriction of all unnecessary manipulation of the fragments both during the transport of the patient as well as in the reduction and first dressing.

The administration of an anesthetic during efforts at reduction is to be especially recommended. Since the introduction of the *x*-ray it has been possible to avoid much of the shock due to efforts to make a diagnosis.

Pulmonary Complications.—The recognition of these presents no difficulties. They are most apt to occur in elderly people, especially in alcoholics. As an early complication the disease usually presents itself in a lobar form, with all of the classic signs of this condition, but is usually not ushered in by a chill.

Later, *i. e.*, about the second or third week, the hypostatic form predominates. This form can be recognized by the appearance of a continued fever of a mild character. The temperature ranges from 101° to 102°, with a corresponding rise in the pulse-rate. Physical examination in these cases is both difficult and unsatisfactory. The disease is present in the posterior portions of both lungs, and gives rise to some dullness and increase in voice and respiratory sounds. All these signs are far less marked than in an ordinary frank pneumonia. The patients are weak and often delirious, gradually becoming unconscious. The prophylaxis of these pulmonary complications consists in avoidance of unnecessary exposure or chilling of the surface of the body in every case of fracture. Patients who are weak and well advanced in years should be given alcohol or some other stimulant during the first two to three weeks. In the colder months of the year the immediate use of a pneumonia jacket is to be recommended. This is practically a vest made up of cotton batting placed between two layers of cheese-cloth. The patients in whom hypostasis is likely to develop are instructed to take frequent deep breaths and, if possible, the fracture should be placed in some form of dressing which will compel them to remain in bed as short a time as possible. The treatment of pulmonary complications of fractures does not differ from the treatment of the diseases under other conditions.

Ischemic Muscular Atrophy.—Atrophy and paralysis of the muscles of the forearm, rapidly followed by flexion contractures of the wrist and fingers, is a complication of fractures of the bones of the forearm which was first described by R. von Volkmann. The contractures develop much more rapidly than those due to nerve lesions, and resist all efforts at reduction. The condition is due to too tight bandaging of the forearm, which causes an anemia of the parts, with resultant muscular degeneration. The muscular fibers are replaced by connective tissue. In the milder cases it can be treated by massage, electricity, and passive movements. Ferguson has reported two cases in which, by plastic operations, the muscles and tendons were separated from the surrounding connective tissue and the flexor tendons of the fingers were lengthened.

Ischemic atrophy less often follows tight bandaging in fractures of the leg. To present such an unfortunate complication care should be employed never to apply a bandage next to the skin and not too tightly.

The Treatment of Compound Fractures.—A compound fracture is one in which there is a communication between the seat of fracture and the external air through a wound in the skin and soft parts. The term open has also been used to distinguish them from a simple or closed fracture in which no such communication exists.

The history of the development of our present treatment of compound fractures is very interesting. Before the introduction of the methods of Lister in the treatment of wounds this form of fracture was regarded as a most formidable injury. The surgeon simply had a choice between primary amputation or death from infection. The mortality from compound fractures was between 40 and 50 per cent.

Immediately after the introduction of antiseptic surgery this fell to 9 per cent.

Volkmann,[14] in 1877, reported 75 compound fractures with no deaths, and only 8 or 11.1 per cent. necessitated secondary amputations. His method was to enlarge the wound, remove all blood-clots and splinters of bone, cut away all tissue and bone-ends which threatened to become necrotic, and provide for ample drainage by making counteropenings so as to drain all pockets of the wound, following this with packing of the area exposed with gauze. This was a happy combination of the open and occlusive treatment. The conclusion was gradually reached, however, by the majority of surgeons that such radical treatment was unnecessary in many instances. Although his results were brilliant as compared to preantiseptic days, they were not as good as the results of the more modern and simpler or so-called conservative treatment. The resection of the ends of the bone and the removal of splinters often favored a pseudarthrosis.

At the present time it is the universally accepted opinion of surgeons that, although every compound fracture may be regarded as an infected wound, yet in the majority of cases the local reaction will overcome the infection unless the latter is of a very virulent type. There has been more and more of a tendency to treat them as simple fractures after a thorough disinfection of the skin and application of the primary dressing.

One of the best classifications of compound fractures is that suggested by Klauber.[15]

1. **Traumatic Amputations.**—In this group we are called upon to treat the ragged stump from which the limb has been partially or completely torn by the traumatism.

2. **Primary Amputations.**—Cases in which a primary amputation must be done immediately because of the nature and extent of the compound fracture. Injuries which indicate so-called primary amputation are extensive comminution of the bone, irreparable damage to the main vessels, nerves, and muscles, and destruction or wide-spread contusion of the overlying skin. Of these, injury to the blood-supply of the limb and extensive comminution of the bone are the most important.

If an amputation is indicated, it is best to do it as soon as possible after the accident (see Volume V). It is best performed when the proper environment has been secured, and must not necessarily be done at the place of injury. If the patient's condition is not such as to justify operation, it is better to wait until he reacts, but one must attend to the hemostasis at once by ligating the main vessels and applying an aseptic dressing.

3. **Débridement.**—This term was introduced by von Volkmann to express operative interference in some cases of compound fractures. It is being less frequently employed from year to year. It is difficult to state which cases should be treated by this method. It is often employed as a substitute for primary amputation in an attempt to save the limb.

The wound in the skin and soft parts is usually quite large in these cases, and there is often extensive comminution of the bone. The best method of treatment of these is upon the principle of Volkmann's débridement adapted to the modern conception of these fractures. Our present experience teaches that the danger of infection of the bone is less than that of the soft parts.

An anesthetic should be given, and a constrictor applied around the limb well above the point of fracture. The skin should be thoroughly cleansed by first scrubbing it with tincture of green soap and sterile water. The parts around the wound must now be shaved, and the soap washed off with sterile water, followed by the application of alcohol, ether, and 1:5000 bichlorid solution in the order named. If much grease is present upon the skin, this can be removed by the use of turpentine. The edges of the skin around the opening which leads to the fracture should be cut away. They are usually infected, ragged, and contused. The wound should be enlarged and irrigated with normal salt solution or sterile water. Strong antiseptics are contra-indicated unless evidences of infection are already present. Under these circumstances the wound should be freely irrigated with 1:5000 bichlorid solution, followed by the application of tincture of iodin into every corner, or pure carbolic acid followed immediately by alcohol. All blood-clots and foreign bodies should be removed. The periosteum of the bone should not be disturbed. Only completely detached bone fragments should be removed. Resection of the end of the fragments is only indicated if one of three conditions be present: (1) If the ends are badly crushed; (2) if the medulla contains dirt; (3) if it is impossible to reduce the fracture. If there is marked displacement, it is best to use some means of fixation, either wire, nails, screws, or some form of clamp. Of all these, the most satisfactory is silver or bronze aluminum wire. Klauber has suggested that in these very serious cases where the danger of secondary infection is great, not only should there be extensive gauze packing of the soft parts, but the ends of the bone are separated by gauze. Later, after the danger of infection has passed or the evidence of its inflammation subsided, the bones can be united by secondary suture. The general practice in America has been to drain the wound with strips of gauze or a cigarette drain (see Vol. III), the greater portion of the wound being sutured. Rubber gloves are worn during all these manipulations. An aseptic occlusive dressing is next applied, and the limb placed upon some form of splint—best of all, a molded plaster one. It is not advisable, in the majority of cases, to apply a circular plaster cast immediately unless provision is made for swelling by cutting it open along its front before it is dry. Provision for dressing the wound can be made by the use of a window in the cast if the latter is employed, the window being lined by dental rubber, as described on p. 120.

It is well to remember that the ordinary splints used in simple fractures can usually be applied in the compound variety. Any constriction must be avoided, and absolute fixation of fragments is seldom necessary before the end of ten days, so that a circular cast, unless cut open as directed, is seldom indicated before this time.

4. **The Conservative Method.**—The policy of non-interference has become the most generally accepted one in the treatment of compound fractures at the present time. This method has as its advantages: (*a*) The lessened danger of infection of the wound through unnecessary contact of fingers or instruments; and (*b*) the conversion of the compound or open fracture into a simple or closed one at as early a period as possible.

The general principles of this method are the following: (1) Thorough disinfection of the skin in the vicinity of the wound; (2) irrigation of the wound if there is suspicion of infection; (3) reduction of fragments which project through the wound; (4) wiring of fragments if there is a great tendency to displacement; (5) treatment of the fracture by the same methods as would be employed if it were of the simple or closed variety.

The skin in the vicinity of the wound should be thoroughly scrubbed with green soap and warm water, and then shaved. The soap should be washed away with warm sterile water, followed by the rubbing of the skin with sterile gauze saturated successively with alcohol and ether.

Care should be taken to rub away from the wound, *i. e.*, centrifugally. The wound itself should now be cleansed by removing any loose particles of bone, dirt, or blood-clots which may be visible. If one of the fragments projects through the skin, it should be washed off with 1:5000 bichlorid solution and replaced within the wound by traction of the limb, etc. If the fracture has occurred in such a manner that the wound has been directly exposed to the dirt of the streets, and, therefore, to the bacilli of tetanus, etc., it is best to irrigate the wound thoroughly with 1:5000 bichlorid solution, followed by sterile water. If there is much tendency to displacement of fragments, the latter can be immobilized by wiring or by one of the other methods referred to under the operative treatment of simple fractures (p. 125). The further treatment of the wound varies. If it is quite large and the edges of the skin contused and ragged, it is advisable to freshen the edges and suture the greater portion of the wound in the skin, inserting a small gauze drain at one angle.

If the wound in the skin is small, it is best to leave it open without inserting a drain.

Some surgeons close the wound completely after the disinfection just described has been carried out. Such is the custom of Trendelenburg, whose results are mentioned later. The wound should be dressed in the ordinary manner with aseptic occlusive materials, viz., sterile gauze and cotton. The immobilization of the limb, application of extension, use of splints and of casts, differs but little from that employed in the treatment of a simple fracture in the same location. It is not advisable to apply a circular plaster cast in a recent compound fracture on account of the swelling and danger of compression of the skin. A molded plaster splint is a far better dressing. Provision should be made, in the application of any permanent splint which is employed, for the dressing of the wound. In fractures of the extremities a fenestrum should be cut in the cast and lined with dental rubber, as described on p. 120. The case should be most carefully watched for any signs of infection or injury of vessels.

If infection has occurred, its treatment depends upon the type. If symptoms of gas bacillus infection (p. 102) appear, a high amputation should be performed at once. The longer the interval between the accident and the appearance of signs of local or general infection, the more favorable is the outlook for saving the limb. The wound should be opened and freely drained. If the infection does not yield to the simpler methods, continuous irrigation of the wound with mild antiseptic solutions, such as acetate of aluminum, or boric or salicylic acids, combined with free incisions and counterincisions, will often save an apparently hopeless case.

If signs of gangrene appear from injury of a vessel, an amputation should be performed as soon as possible.

All the previously described manipulations can be best carried out if a general anesthetic is given.

The most modern statistics upon the results of the conservative method of treatment of compound fractures are those of Klauber,[16] of 84 cases from Wölfler's clinic, and of Rimann,[17] of 216 cases from Trendelenburg's clinic.

Of the 84 cases in Klauber's series, there were 5 deaths, *i. e.*, 5.5 per cent., due to sepsis. Of these, 3 refused operation in time to be of any avail. Fifteen cases, or 17.9 per cent., required secondary amputations or reamputations for sepsis. Of the 15 cases, 4, or 4.8 per cent., died, and 11, or 13.1 per cent., recovered. In the remaining 64 cases (76 per cent.) there was primary union.

Of the 216 cases collected by Rimann, 8, or 3.7 per cent., died. Of these 8 cases, 5 died of fat embolism and 2 of sepsis. Of the remaining 208 cases, 143, or 68.7 per cent., resulted in primary union, and 65, or 31.2 per cent., in secondary union. Of the latter, 12, or 5.6 per cent., required secondary amputation. The large percentage of primary union results is the best proof that the conservative method gives the most favorable results and should be generally adopted.

The treatment of gunshot fractures does not differ in any manner from that outlined for compound fractures.

The wound should never be explored until the skin has been thoroughly cleansed and every precaution taken to avoid infection. The more conservatively a gunshot fracture is treated, the more satisfactory will be the result.

The modern bullet is aseptic, and the wound should be regarded as a clean one until evidences of infection appear. If there is evidence, either upon manipulation or through the use of the *x*-ray, that the bone is hopelessly shattered or that the main artery or vein of the limb has been severed, amputation is indicated. Extensive comminution, if the fragments are not large, will often result in a useful limb if the fracture has not become infected at the time of the primary dressing. The removal of particles of bullet is never indicated unless infection has occurred and they act as foreign bodies.

Treatment of Articular Fractures.—The general principles to be observed in the treatment of this class of fractures will be referred to briefly here. The details in regard to the management of fractures in close proximity to or involving the larger joints will be discussed under the individual fractures. As was stated on p. 93, the most characteristic symptom of involvement of the joint in a fracture is an effusion of blood of varying severity. If this blood is not promptly absorbed, it will give rise to adhesions and shrinking of the capsule with resultant fibrous ankylosis. In the intra-articular variety, *i. e.*, where the fracture line is entirely within the joint, the treatment has but little influence upon the result. There is but little formation of callus, so that the function of the joint is not interfered with, as a rule. One of the sequelæ of this form of joint fracture is the formation of loose cartilages (joint mice). This occurs most frequently in the knee-joint, less often in the elbow, and but seldom in the shoulder or hip. In the para-articular variety the formation of callus seldom interferes with the function of the joint, provided that the displacement of fragments has been corrected. The fracture line does not extend into the joint, but close to it in this variety. An example of this form is the supracondyloid fracture of the humerus. In the treatment of para-articular fractures the essential point is to secure as accurate a reposition of the fragments as possible.

An anesthetic should always be given in order to correct any displacement. After a few days it is well to have a skiagraph made in order to establish the accuracy of the reposition. The dressing to be applied should be one which will permit an examination of the parts to be made from time to time. In fractures in the vicinity of the joints of the upper extremity the dressing should be removed once a week. In those of the lower extremity the mode of fixation generally used is one which will not permit of much examination or treatment of the joints. Fractures of the upper end of the tibia involving the knee-joint (p. 260) should be treated like those of the upper extremity.

Whether massage and passive motion in joint fractures should be begun within the first week or ten days or be postponed until the callus is firm will vary according to the facilities at the disposal of the individual surgeon.

Lucas Championnière, as is well known, has been for many years an enthusiastic supporter of the use of massage for the majority of fractures, especially those in the vicinity of the larger joints. This has been shown to be too radical a method, and I cannot urge too strongly that it would be folly to treat every case with massage and passive motion.

The two chief objects to be accomplished by massage and passive motion are primarily to aid the absorption of the hemorrhagic and serous joint exudates, and, secondarily, to prevent or retard muscular atrophy.

In order to attain these desired results both massage and passive motion must be conscientiously and scientifically given. It is for these reasons that the following conclusions seem at present to be safest for the treatment of joint fractures. If massage can be given by an expert masseur or masseuse, one can safely permit massage in the vicinity of such joints as the shoulder, wrist, fingers, and knee as early as the eighth to fourteenth day. This means that it should be accomplished without disturbing the apposition.

Fig. 75.—Pulley Weight Apparatus for Movements of Shoulder or Elbow.

Passive motion should never be begun even by an expert before the end of the third week, and active motion with or without resistance not until after the fifth or sixth week. To those who have never employed these methods in hastening the early return of function in a joint, the results accomplished by their use will be astounding.

If, however, the services of those skilled in this class of work cannot be secured, it is best to wait until the callus is firm, *i. e.*, after the fourth or fifth week, before beginning massage or motion, either active or passive.

The muscles proximal to the joint should be gently rubbed in an upward direction to facilitate the absorption of any exudates and stimulate the regeneration of muscular fibers. Light passive movements are then begun.

After these movements have been carried out for five minutes the muscles should be kneaded for a variable period. Usually from five to ten minutes is sufficient for the first few sittings, the time being lengthened gradually to one-half hour. If the muscular atrophy is slow in disappearing, the use of the faradic current is indicated, one electrode being placed upon the spine, the other over the motor points of the muscles and along the bellies of the latter. The joints should be treated by the same methods of massage, *i. e.*, gentle friction and kneading. One sitting daily will usually suffice. The massage of the joints and atrophied muscles should be combined with active and passive movements of the joints adjacent to the seat of fracture. The passive movements should be extremely gentle at first, the range of motion being increased from day to day. In children, passive movements are carried out with such difficulty that I have been far more successful in encouraging them to use some simple pulley weight apparatus (Fig. 75), or by the use of the ordinary dumb-bell.

In some cases, especially if the above-described methods cause much pain, various others can be employed. These are the use of hot-air apparatus, of warm and cold douches, of passive hyperemia (see p. 139), and of the various forms of Zander apparatus. In hospitals where a large number of fractures are treated the purchase of some of the Zander machines can be warmly recommended. These are run by electricity and produce passive movements of the major joints with far greater gentleness and accuracy than can be secured by ordinary manual means. In patients subject to rheumatism the healing of an articular fracture is often greatly complicated by a chronic rheumatoid arthritis or by an arthritis deformans which requires the special treatment just described, as well as that of the underlying systemic condition.

The early and systematic use of active and passive movements, of massage, of hydrotherapy, and mechanico-gymnastics cannot be too strongly urged in the treatment of para-articular and articular fractures. The surgeon may lose interest in these cases as soon as firm union has been secured. It is, however, about this time, *i. e.*, as soon as it can be safely manipulated, that the future function of the joint must be cared for, and unless the proper treatment is begun early, ankylosis is very apt to occur.

The principles just outlined apply in the treatment of the third variety of joint fractures, viz., the true articular. The majority belong to this class where the fracture either extends into the joint from without or begins in the joint and extends outward. If much displacement exists, the callus is apt to interfere with the joint function. Every possible effort should be made to secure good apposition of the fragments. If necessary, operative reduction and fixation are indicated in individual cases. Much depends, as in the other varieties, upon the institution of the correct after-treatment, as previously described, before ankylosis can occur.

For the treatment of fractures of the olecranon and patella the special sections should be referred to.

Gunshot wounds of the joints are considered in the chapter on Military Surgery.

The Treatment of Delayed and Vicious Union and of Non-union.—The definition and causes of these complications in the healing of fractures have been discussed on p. 110.

Delayed Union.—This term should be applied to those cases in which a firm union is absent at a period varying from eight to twelve weeks. It is recognized by the persistence of mobility at the point of fracture and the absence of calcification, as shown in a skiagraph (Fig. 53). Delayed union may end in non-union, or ossification of the callus may occur and the union become a perfect one. True non-union, *i. e.*, a true pseudarthrosis, is rare. In the majority of cases the two fragments are held together by fibrous tissue. The first thing to be done when union is delayed is to eliminate, one by one, all the possible causes. The most frequent of all the local causes (see p. 109) is imperfect fixation of the fragments. This is especially true of fractures of the shafts of the humerus, femur, and tibia. The seat of fracture should be absolutely immobilized, either through the application of splints or of a circular cast. In cases of delayed union of the humerus, neglect to immobilize the lower fragments by permitting too free movements of the elbow will often be found to be the cause. A similar condition is found in fractures of the femur or tibia, the hip, knee, or ankle being imperfectly fixed. If the fragments are too far apart, as often occurs in the patella, this can be readily recognized by palpation or an *x*-ray examination. The best method to correct delayed union due to this cause is by operative interference. The interposition of bone, muscle, or of pieces of fascia is a far less frequent cause of delayed union than has been generally believed. It cannot be prevented, and if present, can be recognized by the signs previously given as characteristic of delayed union. The treatment of delayed union from these last-named causes is by operative interference, providing they have been recognized or suspected to be the cause, which, as has been previously stated, is rarely the case.

Among the general causes (see p. 110), the most frequent are syphilis, diseases of metabolism, such as rheumatism, gout, diabetes, scorbutus, rachitis, and chronic nephritis.

A number of cases which are incorrectly diagnosed as delayed union due to some local cause are in reality pathologic fractures. Of these, a large proportion are due to tabes dorsalis, syringomyelia, osteomalacia, and the other causes referred to on p. 83.

General Treatment.—This consists in administering tonics, such as strychnin, iron, quinin, phosphates, or phosphorus. If one of the general diseases just mentioned is suspected to be the cause of the delayed union, the appropriate treatment should be promptly begun.

Thyroid extract given three times daily in 5-grain doses has been found to favor greatly the formation of bone in cases of delayed union.

The iodid of potassium has been found empirically to act in the same manner, especially where a suspicion of syphilis, either congenital or acquired, exists. Medium-sized doses, say 15 to 30 grains, three times daily suffice.

Local Treatment.—1. *Immobilization by Splints, etc.*—The imperfect fixation of the fragments has already been referred to as the most frequent cause of delayed union. Before one of the other local methods to be described is resorted to, this cause must be excluded by an attempt at immobilization, either through the application of a splint or cast for four to eight weeks which will positively not permit any movement at the point of fracture. Some surgeons believe that frequent movements of the ends of the fragments during the period of normal or delayed callus-formation are beneficial to good union. This is an unsafe opinion by which to be guided in the treatment of a fracture.

2. *Other Local Methods.*—These should only be tried if every possible effort has been made to secure bony union by four to eight weeks of absolute immobilization. They are:

(*a*) *Injection of Blood, after Bier.*—Bier[18] has demonstrated from experiments and clinical observation that the effusion of blood between the fragments acts as an excitant of new bone-formation. Hence one should not remove the blood-clots in compound fractures unless there is suspicion of infection. The same holds true in the operative treatment of simple fractures. He has facilitated bony union by the injection of fresh blood between the ends of the broken bones. This is either secured by aspirating it from the veins of the patient or of other individuals. The method is still untried by the profession in general, but seems a rational one.

(*b*) *Rubbing the Ends of the Fragments Together and Drilling of the Bones.*—These are two methods which are worthy of trial, especially in fractures of the tibia. An anesthetic is given, and the limb sharply bent at the point of fracture. By traction and rotation the ends of the bones are rubbed together. The theory upon which this is based is that the imperfectly formed callus is stimulated by reproducing the conditions of a fresh fracture. The same holds true for drilling the ends of the fragments with an ordinary drill. This latter is chiefly applicable to fractures of the tibia.

(*c*) *Passive Hyperemia, According to Bier.*—This consists in applying an elastic constrictor around the limb above the seat of fracture. The color of the skin below the point of constriction should become a dark red, care being taken to avoid the whitish color of complete anemia. The constriction is at first applied for from one to three hours daily, the length of time being gradually increased so that it is kept on during the entire twenty-four hours. Ten days of this treatment will suffice to show whether it is of value in the case.

(*d*) *Operative Measures.*—The principle in all of these is the same, the chief difference being in the form of apparatus or material used to maintain apposition.

The greatest possible care must be exercised to observe the rules of asepsis. A general anesthetic having been given and the parts prepared as for other aseptic operations, a constrictor is applied well above the seat of fracture. The ends of the fragments are exposed and freed of all fibrous tissue covering them. The ends are now resected to an extent sufficient to expose the medullary cavity of the bones. The bones should be squarely sawed across, so that exact end-to-end apposition is secured. There is considerable difference of opinion as to the advisability of using wire or other means of fixation. Stimson believes that equally good results can be obtained by the use of external splints without wire or even absorbable sutures.

Every operator must judge for himself in the individual case. If apposition seems to be maintained when the bones are held together before closing the wound, no suture or other apparatus is necessary. Great care, however, is to be observed in applying a cast or splint to prevent any disturbance in the apposition. If there is the least tendency, however, for a malposition to recur, it is the safest plan to use some form of retention. Silver or bronze aluminum wire are the best non-absorbable materials, and kangaroo tendon and chromicized catgut the best absorbable substances. The Parkhill or Gussenbauer clamps are very useful, but require to be removed, which is a decided objection. Where there is but little tension, as in fractures of the clavicle, olecranon, or patella, absorbable sutures are indicated. In the larger bones, like the adult humerus, femur, or tibia, fine silver wire, two strands being twisted to form one wire, or medium-size bronze aluminum wire, is the best. I prefer the latter in the majority of cases, on account of its greater ductile strength.

The manner in which the ends of the bones shall be drilled will vary somewhat with each case. In general, a single opening through the cortex into the medulla, as shown in Fig. 72, will suffice. Instead of wire or clamps, screws or ivory pegs have been used.

Both of these methods have been employed in fractures of the neck of the femur (p. 237) with success. Arbuthnot Lane is a warm advocate of the use of screws in the long bones.

When the ends of the bones are atrophied or a considerable interval exists, an osteoplastic flap can be made by detaching portions of the bone with the periosteum and wedging them in between the fragments. If there are two parallel bones, as in the forearm or leg, care must be used to remove enough of the uninjured bone so that both will be of equal length.

The union after these operative measures is usually slower than under normal conditions. A firm callus requires six to eight weeks or even longer.

Vicious Union.—When the deformity following union of a fracture is such as either to interfere with the function of the limb or produce disfigurement, operative treatment to correct it is indicated. In judging of the necessity of such a step one must not be misled by the extent of the displacement as seen in a skiagraph. Attention has already been called to a tendency toward exaggeration of the deformity. An overlapping, angular deformity or lateral displacement may be very marked in the skiagraph and yet be scarcely discernible by the ordinary means, such as inspection, palpation, or measurement. In addition to disturbance of function and marked deformity in vicious union, a third indication for operation is the pressure of a callus upon an adjacent nerve (Fig. 50).

Treatment.—After firm union has occurred, the best means of correcting the deformity is by open operation in preference to the use of an osteoclast. An incision having been made down to the seat of fracture, the bone is divided with the chisel in such a manner as to correct the deformity. In some cases of axial rotation a simple transverse osteotomy will suffice. In cases of angular or lateral displacement a wedge-shaped piece of bone must be removed. In cases of vicious union occurring in fractures of parallel bones, like those of the arm or leg, both will require division.

Relation of Sprains to Fractures.—It is with great interest, in connection with the subject of fractures, to note the frequency with which cases that are diagnosed as sprains are in reality fractures. In these cases the separation of fragments is so slight that the diagnosis is not made unless a skiagraph is taken of every case of injury close to the joints. The subject of subperiosteal fractures has already been referred to on page 79. But these cases, which W. W. Keen as early as 1874 referred to as masked fractures, and which have been lately termed sprain fractures by Sir Wm. Bennett ("Brit. Med Jour.," 1906), are in reality unrecognized fractures. The etiology of such cases which are treated as sprains does not differ from that of the fractures which have been treated in the preceding pages. The recognition of these cases of masked fractures or sprain fractures requires the systematic use of the *x*-ray in every case of severe sprain. Not infrequently the case is treated throughout its course as a simple sprain until one of the many consequences appears. One of the most serious of these is stiffness of the adjacent joint; another is the development of a traumatic flat-foot after sprain fractures in the vicinity of the ankle-joint.

The **treatment** depends upon whether there is swelling present or not. In sprains without swelling the first indication is to relieve the severe pain by rest and pressure of the corresponding part by means of strips of adhesive plaster or a bandage snugly applied. Massage is begun after the second or third day, but passive movements are best deferred until the end of the first week. The patient is encouraged to make voluntary movements. In sprains with immediate swelling the best treatment is to place the limb at rest. In some cases it is advisable to apply a splint. A useful splint for severe sprains in the neighborhood of the ankle-joint is the blanket splint described on page 112. In addition to the rest, hot fomentations are applied. Massage should be begun after the first day very gently, but continued twice daily until all the swelling has disappeared. Should massage not be available, skilfully applied strapping is the best alternative. In the treatment of sprains with fracture, the injured part should be kept at rest long enough for the detached portion of bone to reunite, and passive movements are not begun until the end of the second or third week.

Special Fractures.

Fractures of the Nose.—Under this heading are not only included fractures of the nasal bones themselves, but those of the various bones and cartilages which unite to form the skeleton of the nose. These are the nasal bones, the nasal processes of the frontal bones and of the superior maxillæ, the perpendicular plate of the ethmoid, the vomer, the lacrymal bones, the cartilaginous septum, and the lateral cartilages of the nose. Fractures of the nose are almost invariably the result of direct violence, such as a blow or fall upon the nose. The fracture is usually a comminuted one, the chief lines of fracture traversing the lower half of the nasal bones in a more or less oblique direction. The fragments are either displaced backward, causing a flattening of the nose (Fig. 76), or to one side. Most of the fractures of the nose are accompanied by a tear of the mucous membrane of the nose or of the skin covering it. In addition to the fracture of the nasal bones themselves various complications occur:

(1) The line of fracture may extend upward into the frontal bone into the frontal sinus, giving rise to emphysema in the subcutaneous tissues, (2) There may be accompanying fracture of the lacrymal bones or of the nasal processes of the superior maxillæ, causing laceration or compression of the lacrymal duct. (3) The fracture may extend into the bony and cartilaginous septum, causing marked deviation of the septum itself or of the tip of the nose. (4) The line of fracture may involve the anterior fossa of the skull with accompanying concussion of the brain or other symptoms of intracranial injury. (5) The lateral cartilages may be torn from their attachments to the nasal bones and superior maxillæ. This last-named complication may occur independently of a fracture of the nasal bones, and must be borne in mind in the examination of an injury to the nose.

Fig. 76.—Widening of Nose following Compound Fracture of the Nasal Bones in Boy of Ten.

The flattening of the nose following a fracture greatly resembles that due to syphilis.

Symptoms.—The recognition of a recent fracture of the nose presents no difficulties. After a few hours, when swelling has occurred, it is far more difficult. It is usually advisable to administer an anesthetic, both for the purpose of making an exact diagnosis and of correcting the deformity. Abnormal mobility and crepitus are best elicited by grasping the nose between the index and middle fingers of both hands and gently moving the nose from side to side. The extent of injury to the septum can be determined by inspection through the anterior nares with the aid of a nasal speculum. At times the injury to the septum will be the only result of the violence

In other cases the deviation of the septum is but little marked at the time of injury, gradually increasing until it is quite apparent at a later period. The fracture of the septum usually occurs in the posterior two-thirds of the cartilaginous and in the anterior half of the bony septum. The chief deviation of the septum may be at the tip, causing it to be displaced laterally. The most common form of fracture of the septum accompanying injuries of the nasal bones or occurring independently of them is a horizontal one, causing a gutter-like deformity running parallel with the floor of the nose. The convexity can be seen through one naris, the concavity in the other. The injury to the septum causes considerable difficulty in breathing.

Epistaxis is an almost invariable accompaniment of fractures of the nose, and may be so profuse as to require gauze tamponade. If the fracture extends into the frontal sinus, there is emphysema over the upper half of the face, which is increased when the patient sneezes or blows his nose. The involvement of the lacrymal duct is seldom recognized at the time of injury. It causes the condition known as epiphora, the tears flowing over the cheek. A Bowman's probe passed through the orifice of the duct at the inner canthus of the eye shows it to be obstructed. In some cases of fracture of the nose the predominant symptoms are those of the complicating intracranial injury. A late complication of fractures of the nose is a periostitis or perichondritis of the bones or cartilages, resulting from the infection of the seat of fracture. These complications can be recognized by the presence of a fetid odor and a purulent discharge, accompanied by dull pains over the frontal region. The nose remains swollen and sensitive to pressure, and the condition persists until the necrotic bone or cartilage is removed.

The **prognosis** of fractures of the nose is good unless cerebral complications exist. The deformity, unless corrected within a few days, becomes a permanent one, firm union occurring, as a rule, after two or three weeks.

The **treatment** depends upon the amount of displacement. If there is but little external deformity and no evidence of injury of the septum, moist dressings or an ice-bag should be applied over the nose, the patient being kept quiet until all of the swelling has disappeared.

If much external deformity exists, the fragments can be reduced by combined external and internal manipulation. This is best carried out by inserting an eight-inch forceps, the blades of which are covered with gauze, through the anterior naris, first of one and then of the other side, while the other hand upon the outside pushes or molds the fragments into place. In this manner displacements backward or to the side or a spreading of the cartilages can be completely corrected. There is but little tendency for the deformity to recur, except when there are many fragments and the septum is extensively fractured.

The fragments are best held in place by some support from within, such as gauze wound around rubber tubing or the Asch tube, one of these being placed in each nostril. If the bones are broken high up, the upper part of the nose should be tightly packed for three to four days with strips of gauze.

The writer's modification of Cobb's nasal splint (Fig. 78) will be found very useful in maintaining the reduction of the fragments, both in cases of fractures of the nasal bones and in cases of separation of the lateral cartilages of the nose alone. This consists of a tin pad for the forehead attached to a cloth strap with a buckle in back for fastening it firmly around the head. By the use of two wire arms at the lower ends of which leather pads are fastened pressure can be made upon the sides of the nose, either continuously or for a few hours daily. The amount of pressure can be regulated by turning the screws inserted at the point of attachment of the wire arms to the pad on the forehead.

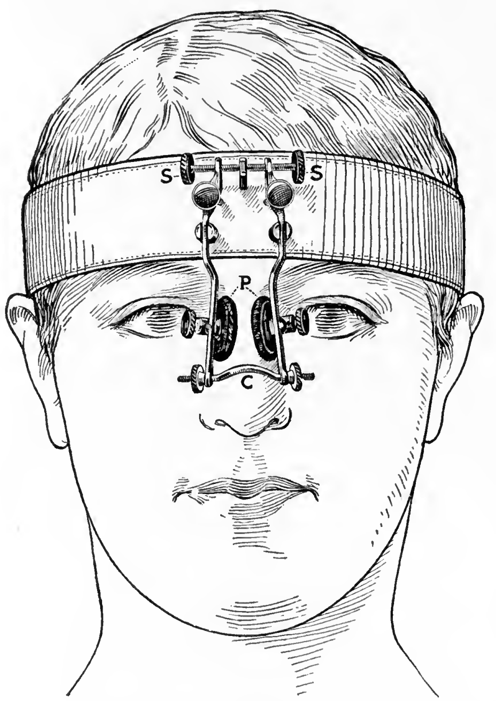


FIG. 77.—EISENDRATH'S MODIFICATION OF THE COBB NASAL SPLINT.

S, S, Screws for adjusting pads, P, to sides of nose; C, bridge to hold pads in position after they have been adjusted.

The internal deformity should be corrected at the same time as the external, otherwise it tends to increase and cause serious obstruction to breathing through the nostrils. If the case is seen soon after the injury, the deviation is not difficult to correct. This is best accomplished by inserting the blade of an eight-inch forceps well protected by gauze through each anterior naris and thus exerting pressure upon both sides of the septum. After correction of the deformity it can be maintained by the use of the Asch tubes or heavy rubber tubing covered with gauze or asbestos packing.

All the previously described manipulations should be carried out under anesthesia, either local (cocain) or general. The latter is preferable. The utmost care should be taken to prevent infection at the time of reduction and during the subsequent course of the case. After removal of the gauze or tubes the nose should be irrigated with Seiler's solution.

In cases of deformity following fractures of the nose seen at a later period, when union is firm, the treatment is very difficult. Paraffin injections (see Volume III, on the Surgery of the Nose, etc.) have been employed to correct the saddle-nose deformity, but the method is too uncertain in its results to be recommended. The lateral deformities can be corrected by plastic operations or by manipulations similar to those employed in recent cases. No attempt to correct post-traumatic deviations of the septum should be made for at least six months to a year after the injury, on account of the danger of infection and of necrosis of fragments. The best operation is the submucous resection, as performed for deviations of non-traumatic origin.

Fractures of the Malar Bone.—From its exposed position one would expect to find fractures of the malar bone frequent after a blow or fall upon the side of the face. That such a fracture is an infrequent occurrence is due to the fact that it is a very compact bone, forming an excellent protection to the upper jaw and the adjacent orbit and antrum of Highmore. Fractures of the malar bone are best divided into—(*a*) Those of the zygomatic arch; (*b*) of the body; (*c*) sutural disjunction. (*a*) Those of the arch alone are rare, and due to blows with or falls upon sharp objects. (*b*) Those of the body constitute the majority of all fractures of the malar bone. The body is crushed toward the superior maxilla, the fracture line almost invariably extending into the latter bone. The entire malar bone is depressed, and the fracture line traverses the facial surface of the superior maxilla, passing through or near the infra-orbital foramen, and then obliquely downward and outward across the superior maxilla, opening the anterior wall of the antrum. (*c*) In the third variety of fracture of the malar bone a separation of the bone occurs at its junction with the superior maxilla and with the zygomatic process of the temporal bones respectively. This sutural disjunction is very rare, only four cases having been found by Sourdille.[61] I have recently seen such a fracture following a blow upon the zygoma in a man of twenty-three. The typical displacement is a rotation of the malar bone so that the end of its maxillary process is tilted upward, being felt as a projection along the lower margin of the orbit (Fig. 78). At the middle of the zygoma a depression can be felt,

Fig. 78.—Fracture of Malar Bone.

A frequent seat of fracture of the malar bone along the lines shown, namely, at its junction with the superior maxillary and the zygomatic process of the temporal bone. The arrows show the direction in which the fragments composed of the entire malar bone are dislocated.

due to the separation of the zygomatic processes of the temporal and malar bones.

In all fractures of the malar bone there is considerable swelling of the overlying soft parts and extensive discoloration of the skin, due to hemorrhage, especially into the eyelids and conjunctiva. The swelling is often so marked that the suspicion of a fracture does not arise until deformity appears. The examination should always be made as soon as possible after the injury. Mobility and crepitus are rare and very difficult to elicit. The chief symptom is deformity. This can be found by careful inspection and palpation of the bone (Fig. 79). In fractures of the body there is a depression or flattening over the outer upper part of the face instead of a prominence due to the malar bone.

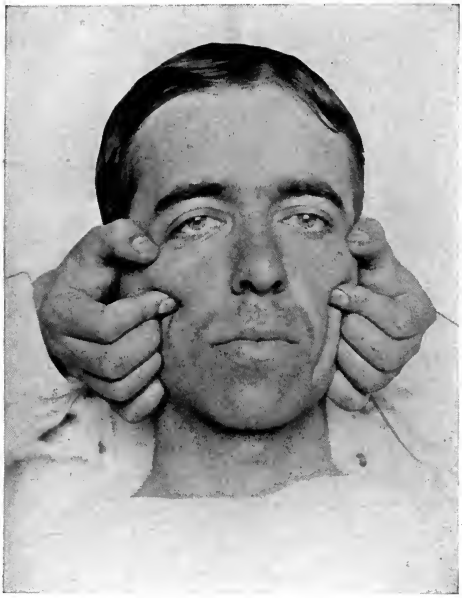


Fig. 79.—Method of Palpating Malar Bones in Examination for Fracture.

If the fracture line traverses the infra-orbital foramen, there is anesthesia or paresthesia of the upper part of the cheek or of the gums or teeth of the upper jaw.

If, as is usually the case, the anterior wall of the antrum is broken, there is moderate epistaxis. In fractures of the arch alone or in a sutural disjunction there is a palpable deformity. The zygomatic arch may be found depressed inward, interfering greatly with the movements of the lower jaw.

If the deformity has not been corrected, a visible depression usually remains. Limitation of the movements of the temporomaxillary joint is rare.

Treatment.—It is almost impossible to correct the deformity without operative interference, owing to the inward displacement of the fragments in fractures of the body and arch, and of rotation of the bone in a separation at the sutures.

There are three methods of operating: (*a*) A direct, *i. e.*, an incision is made through the skin and the fragments pulled outward. This is objectionable on account of the scar and the inability to retain the fragment in place. (*b*) Through the mouth by inserting blunt instruments beneath the bone from within and lifting the fragments up. By this method it is difficult to maintain the fragments in position until union has occurred. (*c*) The third method is that of Lothrop. He recommends making a small incision through the mucous membrane of the mouth, just over the canine fossa, and through an opening in the anterior wall of the antrum to lift up the fragments, packing the antrum with gauze which is not removed for four to five days. This would seem like an ideal method were it not for the danger of infection. This is avoided by frequent washings of the mouth with mild antiseptic solutions. The method has been employed by Lothrop in a number of cases and is well worthy of trial.

Fractures of Upper Jaw.—These are associated, in the majority of cases, with fractures of the nasal or malar bones, and, like these, are often compound, the fractures communicating with the nasal or buccal cavities or with the antrum of Highmore.

The most frequent cause is a blow upon the face, a gunshot wound, being run over, or as a result of the explosion of a shell during war. Fractures of the body are rare as compared with those of its processes. In general, one can distinguish—(*a*) fractures of the alveolar processes; (*b*) of the body. The former most often occur in connection with extraction of the teeth or by a blow upon the teeth. Fractures of the body are either found as simple fissures or as comminuted fractures involving the anterior wall of the antrum. The fissures often extend into the adjacent bones, and, vice versa, are often a complication of fractures of these bones, especially of the malar.

In comminuted fractures, especially after gunshot wounds, the fragments are either driven inward into the antrum or upward into the orbit. In some cases the upper jaw of one side may be separated from its fellow, and one or both displaced downward and backward. A number of such cases of complete diastasis or separation have been reported following a kick upon the face or a fall from a height.

Transverse, *i. e.*, horizontal, lines of fracture follow a blow received below the nostrils. The alveolar and palatal processes can thus be completely separated from the body of the bone.

Diagnosis.—The diagnosis is easy. If there is no displacement of fragments, inspection of the upper jaw through the mouth will show a gap in the mucous membrane which bleeds. By grasping the jaw on either side of this between the fingers of both hands abnormal mobility can usually be elicited.

If there is displacement of fragments, the cheek is flatter and palpation of the facial surface of the bone, either through the cheek or from within the mouth, will show a depression over the antrum. The teeth will show irregularity in alinement. The direction and extent of fissures can seldom be estimated unless displacement has occurred. Epistaxis and emphysema of the upper part point to involvement of the antrum of Highmore. There is marked swelling of the cheek and mucous membrane of the mouth and palate. If a diastasis of the entire upper jaw has occurred, the diagnosis can be readily made by the deformity, and the abnormal mobility of one superior maxilla against the other.

Prognosis.—This is in general good unless infection of the antrum or intracranial complications are present.

Necrosis of the alveolar processes is usually slight, that of other portions of the bone rare. If the infra-orbital or palatine nerves are caught in the callus, severe neuralgia may result. Division of the lacrymal duct may lead to a stenosis, causing epiphora. If an empyema of the antrum occurs, it may continue for some time.

Treatment.—In fractures of the alveolar processes every effort should be made to save the teeth. Although quite loose at the time of injury, the teeth may become firmly attached again. A retentive apparatus is rarely necessary, great care being used to maintain a clean condition of the mouth by frequent antiseptic washes and the administration of liquid food. Loose fragments of bone should be removed with scissors and forceps.

In fractures of the body of the bone with irregularities in the teeth the deformity can be corrected by inserting blunt instruments through the opening in the gums and lifting the fragments into their proper position. If there is no tendency to recurrence of the displacement, a Martin bandage can be applied and the same after-treatment given as in fractures of the alveolar process. If there is tendency to displacement after reduction of the fragments, a gutta-percha splint can be made by a dentist to hold the upper against the lower jaw, assisted by an external bandage. In cases of complete separation of the upper jaws from each other wiring may be necessary. The treatment of comminuted fractures without much displacement consists in the employment of every precaution to prevent infection as previously given and as in the case of all fractures of the upper jaw continued for a period of six weeks to two months.

Fractures of the Lower Jaw.—Fractures of the lower jaw are far more frequent than those of any of the other bones of the face. They are usually the result of direct violence, such as blows, gunshot wounds, or of falls upon the bone. In a few cases the fracture has been the result of indirect violence. In some of the latter the jaw was compressed from side to side, and, as in the case of fractures of the skull, yielded at the point where the elasticity was insufficient, viz., at the symphysis. A second variety of indirect fracture is that of the condyles following a blow or a fall upon the chin. The coronoid process can also be torn off by violent contractions of the temporal muscle.

The four most common seats of fracture are:

1. The alveolar processes.
2. The articular processes (condyles).
3. The ramus.
4. The body.

Those of the body are the most frequent, while those of the ramus, condyles, and coronoid processes are comparatively rare.

Fractures of the alveolar process are usually partial, and occur after extraction of the teeth or a blow upon the latter. A complete breaking off of the alveolar process with the tooth contained therein is infrequent.

Fractures of the body of the jaw may be single or double. The most frequent seat is at or near the median line. Of these, the fractures just lateral to the median line form the majority, the line of fracture being either between the incisor teeth or between the latter and the canine tooth. The direction of the fracture is either vertical or oblique.

Displacement of fragments is usually greatest near the median line. This is due to the traction downward of the depressors of the lower jaw upon the central or inner fragment, and the upward and inward pull of the masseters and pterygoids upon the outer fragment (Fig. 81). As a result of this double action the teeth are out of line, and one fragment lies behind the other. Symmetric, *i. e.*, double, fractures of the body are not uncommon, especially in the region of the incisor teeth.

The intervening fragment is pulled downward and backward. This displacement may be so marked that the tongue falls backward, closing the glottis and causing asphyxia. Double fractures lateral to the incisor teeth are less frequent than those of the latter region. The line of frac-

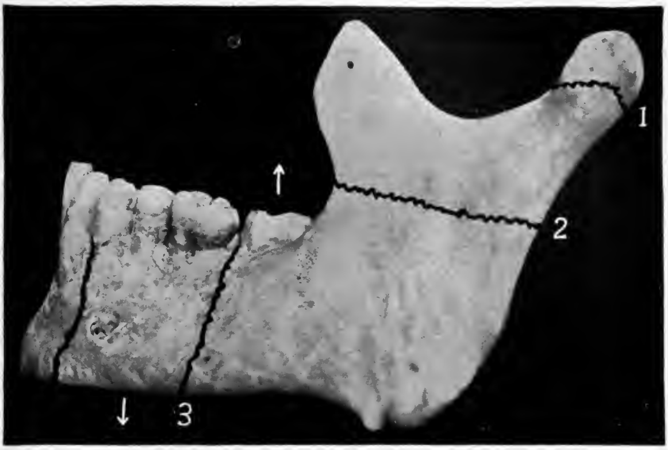


Fig. 80.—Location of Most Frequent Fracture Lines of Various Portions of the Jaw.

1, Fracture of condyloid process extending into temporomaxillary joint; 2, fracture of ramus of jaw; 3, fracture close to junction of ramus and body. The white arrow to the right of 3 shows the direction in which the masseter muscle pulls the proximal fragment upward, and the arrow to the left of the 3 shows the direction in which the muscles attached to the lower jaw close to the median line pull it downward.

ture in the vicinity of the molar teeth is usually oblique, and there is less tendency to displacement. In fractures of the body of the jaw the inferior dental nerve may be torn or compressed, causing anesthesia of the gums and chin or severe neuralgia. The majority of fractures of the body and ramus are compound, there being direct communication between the seat of fracture and the mouth through a tear in the mucous membrane.

Fractures of the ramus are usually oblique from above and forward in a downward and backward direction. There is but little displacement unless the fracture is bilateral. Under the latter circumstances the body and remainder of the ramus may be displaced upward or laterally. Fracture of the neck of the condyles is not as infrequent as has been generally supposed. Roe[20] found it in six of forty-one cases of fracture of the lower jaw.

In one case it was bilateral. It is a frequent cause of ankylosis of the adjacent temporomaxillary joints. Orlow[21] found falls or blows upon the chin to be the cause of such an ankylosis in 23 out of 104 cases.

Fracture of the coronoid process is quite rare. The cause is supposed to be a violent contraction of the temporal muscle.

Diagnosis.—The symptoms of a fracture of the lower jaw are usually so marked that the diagnosis is readily made. The best method of examination is that shown in Fig. 82. The jaw is grasped by the thumb and index-finger of each hand placed on either side of the suspected seat of fracture.

Abnormal mobility and crepitus can thus be obtained in the majority of cases. Another positive sign is the disturbance in alinement of the teeth, *i. e.*, there will be more or less of a difference in the level of the teeth. This varies according to the degree of displacement of the fragments, being most marked in fractures near the median line. The gums are swollen and torn at the seat of the fracture, and the teeth may be broken off or loosened. Involvement of the inferior dental nerve can be recognized by the presence of anesthesia over the chin. In gunshot wounds there may be extensive comminution. Severe hemorrhage may be a complication of such cases, due to a laceration of the facial or internal maxillary arteries. Necrosis of bone with the formation of abscesses in the soft tissues over the outer surface is present in some cases. Fractures of the ramus can be best recognized by inserting two fingers of one hand into the mouth and palpating the ramus, while the fingers of the other hand are placed upon the outer side. In this fracture abnormal mobility and deformity can often be found. In some cases the displacement is quite extensive, the lower fragment being distinctly palpable through the cheek. Fractures of the ramus are usually accompanied by difficulty in mastication.

Fig. 81.—Most Frequent Location of Fracture Lines in Unilateral or Bilateral Fractures of the Lower Jaw.
The white arrows point in the direction along which that portion of the jaw is pulled which lies external to the line of fracture.

Fractures of the neck of the condyle show a depression in front of the external meatus, and the condyle can be felt not to follow the movements of the lower jaw. The symptoms of concussion of the brain often accompany fractures of the condyles.

Stomatitis is a frequent complication of all fractures of the jaws unless great care be taken to keep the mouth clean.

Prognosis.—The majority of fractures of the jaws heal within four to six weeks. Non-union is very rare. The frequency of ankylosis of the temporomaxillary joints after condylar fractures has already been referred to. Pressure upon the inferior dental nerve may cause atrophy of the alveolar processes and gums and loss of the teeth. Septic bronchitis and bronchopneumonia are possible complications in cases where a marked stomatitis is present.

Treatment.—The first essential is complete reduction of the fragments in order to correct any disturbance in the alinement of the teeth. This is accomplished by grasping the fragments in the manner employed in making a diagnosis (Fig. 82). By traction and manipulation perfect apposition can be readily secured, but there is often considerable difficulty in maintaining it. If no tendency to displacement exists after reduction, the fragments can be kept in good apposition by using a four-tailed or a Martin bandage, aided in some cases by a metal Levis or a gutta-percha splint applied upon the outside of the jaw. If there is any tendency to displacement of fragments, one of two methods of treatment must be considered: (*a*) the use of an interdental splint; (*b*) wiring the bone. Wiring the teeth adjacent to the seat of fracture or wiring the lower to the upper jaw is an inefficient method of treatment.

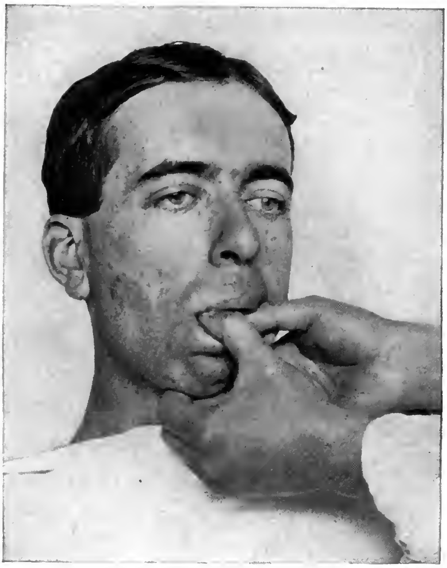


Fig. 82.—Method of Grasping Jaw (Lower), in Order to Determine Fractures of the Lower Jaw.

The index and middle fingers of both hands are placed inside of the mouth on either side of the fracture line, the remaining fingers being placed on the lower border externally, the two fragments then moved against each other in upward and downward directions alternately.

Multiple fractures are much more apt to be accompanied by displacement and require special means of retention than are single fractures.

A large variety of interdental splints have been suggested in the treatment of fractures of the jaw. There are four groups of these splints.

1. Those in which the apparatus fits as a wedge between the upper and lower teeth (as in the splints of Lederer, Fuller, and others).

2. Those in which reduction is maintained by a single splint fastened to the lower teeth, as in the methods of Angle and the interdental wire splints of Hammond.

3. Those in which an interdental plate is held in position by strips

attached to long arms projecting from the plate, as in the apparatus of Kingsley, Gunning, Marshall, and Trauman.

4. Those in which there is both downward (interdental) and upward (chin) pressure, as in the splints of Wales, Sudduth, Bullock, Moriarty, and Matas. The majority of these splints require the services of a dental surgeon. In the larger cities it is possible to secure the services of those who are able to take charge of such cases. In most instances patients with a fracture of the lower jaw are treated by a general surgeon. All devices which have the normal teeth as their anchorage are unstable and cannot be used when no teeth are present.

The use of interdental splints is to be especially recommended in cases of multiple fracture. In these there are two or more points of fracture, accompanied by displacement of fragments.

The usual sequelæ of these cases, if treated by the ordinary methods, are suppuration, necrosis, and interference with mastication, owing to the disturbance in alinement of the teeth. The greatest amount of displacement is found in cases in which the body is broken bilaterally between the second molar and the lateral incisor. The best method of treatment for these cases is either to use the interdental splints of Hayward, Kingsley, Gunning, and of Bean or to wire the fragments.

Fig. 83.—Modeling Cups. A, Used for the upper jaw; B, used for the lower jaw (Scudder).

The Kingsley splint is the one most commonly used.

The Making of the Dental Splint.—If an impression is desired of the crowns of the teeth and the adjoining gum, it is best made by using the modeling composition manufactured for the use of dentists. The necessary amount of the composition is dropped into hot water; when soft, the composition is put into the metal impression-cups (Fig. 83). The surface of the composition is warmed by holding it over a flame or holding it again in hot water; then the impression-cup containing the softened composition is placed in the mouth and the impression made. Immediately upon the removal of the mold from the mouth the composition cools and hardens. From this mold is made the duplicate of the alveolar border and the teeth in plaster-of-Paris (Fig. 84). The lines of fracture are clearly indicated upon the plaster cast. With a fine saw the cast is cut upon these lines and the lower teeth are articulated with the plaster cast of the upper jaw, which has been made. Plaster cream is used to hold the sawed portions together. In other words, the fracture has been reproduced and reduced in plaster-of-Paris. Both upper and lower casts are then put upon an articulator (Fig. 85). A vulcanite or aluminum splint is made from this reconstructed lower jaw, and when this is applied to the fractured jaw as an interdental splint, the deformity is corrected and comfortably prevented from recurring.

In the absence of a competent dentist, wiring the teeth together can be employed, using No. 26 gage German silver wire. Interdental splints are of no value in the treatment of fracture of the angle, ramus, coronoid, and condyloid process alone. In such a case either wiring for fractures of the ramus or angle, or immobilization by external bandages or wiring the teeth or the use of the apparatus of Angle is indicated. Suture of the fragments is best accomplished by making an incision parallel to and a little below the lower border of the lower jaw, and exposing the seat of fracture. The fragments are then drilled with a small drill, one on either side of the fracture. The wire is then passed through the hole upon one side, back through the hole of the opposite side, the ends brought together and twisted until the fractured ends are approximated. The wire is then cut short and bent down. Silver wire is employed by many surgeons. I prefer a fine bronze aluminum wire—it is not so

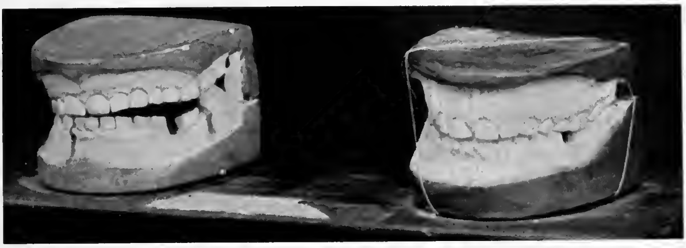


FIG. 84.—PLASTER CAST OF FRACTURE OF THE JAW (Scudder).

FIG. 85.—PLASTER CAST OF LOWER JAW ARTICULATING WITH UPPER JAW (Scudder).

liable to break while being twisted as is silver wire. This accident can be avoided with silver wire if a fine gage is taken and twisted before being used. Abscess of the jaws frequently follows a fracture and should be opened through the mouth, if possible.

Fractures of the Hyoid Bone.—These are rare and always due to direct violence. Of 13 cases collected by Gibbs, 7 followed strangulation, 3 after blows or a fall, and 3 as a result of muscular action. The most frequent seat of fracture is in one of the greater cornua, at or near its junction with the body. There is considerable displacement of the fragments, the pharynx often being punctured.

Diagnosis.—The most characteristic symptoms are: (*a*) A sharp pain over the bone when the mouth is opened or the tongue protruded; (*b*) great difficulty in swallowing, so that it is impossible to take even a few drops of water; (*c*) a visible swelling and ecchymosis appears over the hyoid bone; and (*d*) considerable dyspnea is usually present. Other symptoms are difficulty in speaking, hoarseness, and a distressing cough. If the mucous membrane has been perforated, a profuse hemorrhage may occur. In a few cases abnormal mobility of the cornu has been found by grasping the hyoid between the fingers of both hands. The prognosis is often quite grave on account of the accompanying injuries.

Treatment.—The fracture can be reduced by inserting one finger into the mouth and placing the other hand over the bone upon the outside of the neck. The patient should be kept very quiet, an ice-bag placed over the hyoid bone, and food given per rectum for the first few days.

Fractures of the Larynx.—The thyroid and cricoid cartilages are most frequently involved. In 124 cases collected by Hofmann there were 63 of isolated fracture of the thyroid and 17 of the cricoid. The causes are blows, falls, hanging, and attempts at strangulation.

Diagnosis.—The symptoms are quite similar to those of fracture of the hyoid. The pain upon swallowing is usually greater. Dyspnea and cyanosis are very characteristic symptoms. Upon palpation abnormal mobility and displacement of the fragments can be found unless too much swelling exists.

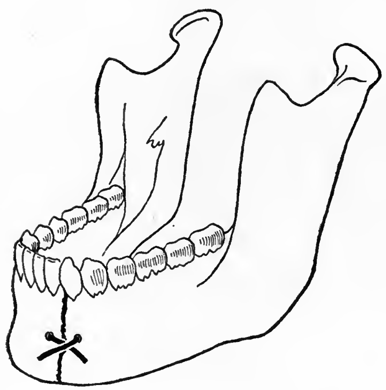


Fig. 86.—Method of Wiring Lower Jaw.

Treatment.—Unless a correct diagnosis is made and prompt treatment instituted, death will occur from the entrance of blood into the trachea or spasm or edema of the glottis.

Tracheotomy should be performed as soon as a diagnosis is made, even though the cyanosis and dyspnea be only of moderate degree. Later on an attempt can be made to correct the displacement.

Fracture of the Trachea.—These are comparatively rare. They are the results of stab or gunshot wounds or of suicidal attempts.

Symptoms.—The symptoms, as in fractures of the larynx, are those of a stenosis of the air-passages. They are stridor, dyspnea, asphyxia, and hoarseness. Not infrequently there is emphysema of the subcutaneous tissues.

The **treatment** consists in performing tracheotomy as soon as possible and aspirating the blood which has escaped into the trachea.

FRACTURES INVOLVING THE THORAX.

Every patient who has sustained an injury of the thorax should be systematically examined to see if one or more of the following conditions are present:

1. Fracture of the sternum.
2. Fractures of the ribs or costal cartilages.
3. Fractures of the scapula.

4. One or more of the intrathoracic or intra-abdominal complications to be described under fracture of the ribs.

5. Associated injury of the spine.

For a description of this last-named condition see chapter on Surgery of the Spine.

Fracture of the Sternum.—In spite of the exposed position of this bone, fractures very rarely occur. This is due to its great elasticity and spongy structure and the yielding of the ribs. Direct violence, such as a blow or a fall upon the sternum, is a far less frequent cause than indirect violence. The manner in which a fracture occurs indirectly is usually as the result of a sudden bending forward or backward of the spine. In some of the cases the head was caught by the edge of a bridge while driving beneath it, and the sternum suddenly bent. The association of a fracture of the vertebræ with one of the sternum has been frequently observed. In a recent case the fracture of the sternum was accompanied by the condition known as traumatic spondylitis of Kümmell at the cervicodorsal junction. (See Chapter on Spine.)

The fracture is almost always transverse and complete. The seat of fracture is at the junction of the manubrium and gladiolus in the majority of cases. Fracture of the body of the sternum at the level of the third rib and separations of the ensiform process are quite rare. The lower fragment is displaced in front of the upper, seldom behind it. It is impossible to distinguish a fracture from a simple separation, called a diastasis, at the junction of the manubrium and gladiolus.

Diagnosis.—The diagnosis may be made from the presence of severe pain at the point of fracture, accompanied by a deformity. Crepitus and abnormal mobility can seldom be elicited, and no effort should be made to obtain these signs of fracture. The deformity is present in one of two forms: (*a*) as a sudden sharp, step-like elevation at the junction of the manubrium and gladiolus, best felt when the fingers are passed along the bone, or (*b*) as an angular prominence at the level of the second rib (angulus Ludovici) or at the junction of manubrium and gladiolus.

The **symptoms** of intrathoracic or of spinal injury often predominate to such an extent that a fracture of the sternum is easily overlooked. If there is considerable hemorrhage into the mediastinum, dyspnea becomes a marked feature. If there is injury of the lungs, hemoptysis and rapid respirations are present.

Prognosis.—Simple uncomplicated fractures heal in four to six weeks. A moderate amount of displacement of fragments does not interfere with callus-formation.

The chief danger is from the cardiac, pulmonary, and spinal complications. Unless these exist, the prognosis is good.

Treatment.—Unless marked displacement of fragments or some intrathoracic complications exist, it is best to relieve the pain by the use of opiates and the application of ice locally. If marked displacement is present, it is advisable to attempt reduction by traction, aided by direct pressure over the point of fracture.

The body is bent backward by placing a firm support beneath the shoulder, while the arms are drawn upward and pressure made upon the lower fragment. If reduction by this manipulation is impossible, an incision can be made and the fragments reduced. Care should be taken not to injure the membrane on the posterior surface of the sternum.

This procedure is especially indicated if there is reason to believe that the dyspnea or cyanosis is dependent upon the dislocation of fragments.

Fractures of the Ribs.—These occur very frequently on account of their exposed position and the lack of support from within. They are very rare in children because of the marked elasticity of the ribs. Their frequency increases from the age of thirty upward on account of the greater exposure to accidents and the increased brittleness of the bones.

The most common cause is external violence, such as a blow or fall upon the chest or a compression of the thorax as the result of being caught between cars, being run over, etc. It is difficult to distinguish direct

Fig. 87.—Method of Determining Crepitus and Abnormal Mobility in Fracture of the Ribs. (See text.)

from indirect violence. In general it may be said that the ribs break at the point where the force comes in contact with them if it is due to direct violence. If, however, the thorax is compressed from before backward, the ribs break at the point of least resistance. In fractures by direct violence the ribs are usually broken at the front or anterior half of the chest, and only one or two ribs are involved. In those following indirect force (Fig. 90) the fracture may occur anywhere. In this vicinity the fractures are often bilateral and many ribs are involved. Fractures of the ribs are rarely the result of violent muscular efforts, such as sneezing, coughing, etc. It is well known that fractures of the ribs occur frequently in the insane, as well as in those suffering from osteomalacia or rickets.

Fractures of the ribs are either complete or incomplete. The latter usually occur as infractions upon the inner aspect, without tearing of the periosteum. In some cases of complete fracture the displacement is slight, owing to the fact that the periosteum has not been torn. In the majority of complete fractures there is overlapping of fragments, or angular deformity is found. The latter gives rise to an elevation or depression as the angularity is in an inward or outward direction. In double or multiple fractures the intervening loose fragment often moves in and out during breathing.

Diagnosis.—The most frequent seats of fractures are the third to ninth ribs inclusive. The diagnosis of a fracture of the ribs depends upon the presence of two classes of symptoms: (1) Those due to the fracture proper, such as pain, crepitus, abnormal mobility, and deformity. (2) Those due to injury of the intrathoracic or abdominal viscera.

(1) *Signs Due to the Fracture Proper.*—These are not as easily elicited as in the long bones of the extremities. It is unnecessary to obtain all of them in order to make a diagnosis of fracture. In partial fractures the only symptom is the presence of pain at the seat of injury. This is seldom sufficient evidence upon which to base a diagnosis of fracture. In complete fractures, one of the most valuable signs is the presence of a well-localized pain. This is increased by forcible expiration, such as sneezing, coughing, etc., or by pressure of the examining finger.

Fig. 88.—General Traumatic Emphysema following Fracture of Right Seventh Rib.

The cheeks, arms, neck, and trunk were quite tympanitic (Prof. Robert D. Murray, I. M. S.).

Each rib should be palpated along its entire length for the presence of this localized pain and the other signs of fracture.

Crepitus can seldom be elicited, and no great weight should be laid upon its absence. At times it can be felt by placing the hand flat upon the suspected point of fracture and asking the patient to cough or breathe deeply. Another method of finding crepitus is to place the hands upon the ends of the ribs while moving the fragments upon each other (Fig. 87). Occasionally crepitus may be heard through the stethoscope. The crunching noise of bony crepitus must be distinguished from that due to emphysema in the skin or a pleuritic friction rub. Abnormal mobility of the ribs is very difficult to find on account of the elasticity of the ribs. It can be obtained either by direct palpation over the seat of fracture or by placing the hands on either side of the fracture. If the fragment is loose, as occurs in a multiple fracture of a rib, the excessive mobility of this fragment renders the diagnosis easy.

Deformity is very difficult to find and is rarely sufficiently marked to be of value. At times one can feel a localized depression or elevation.

In some cases the diagnosis must be made from the presence of a localized pain and a slight depression alone.

Emphysema of the skin or evidences of hemothorax or pneumothorax are positive signs of a fracture of the ribs. The emphysema varies greatly in degree. It may be quite localized over the same side of the thorax as the fracture, or it may extend rapidly all over the body and become a serious menace to life.

(2) *Signs Due to Intrathoracic or Abdominal Complications.*—(*a*) *Traumatic Asphyxia.*—This can be recognized by the marked cyanotic discoloration of the skin of the head, face, and neck. The cyanotic hue terminates very abruptly in the skin of the neck (Vol. I, p. 909, and Pl. xviii).

(*b*) *Injuries of the Pleura and Lungs.*—A moderate degree of subcutaneous emphysema or of pneumothorax which does not increase in severity, or the presence of localized friction sounds, is indicative of involvement of

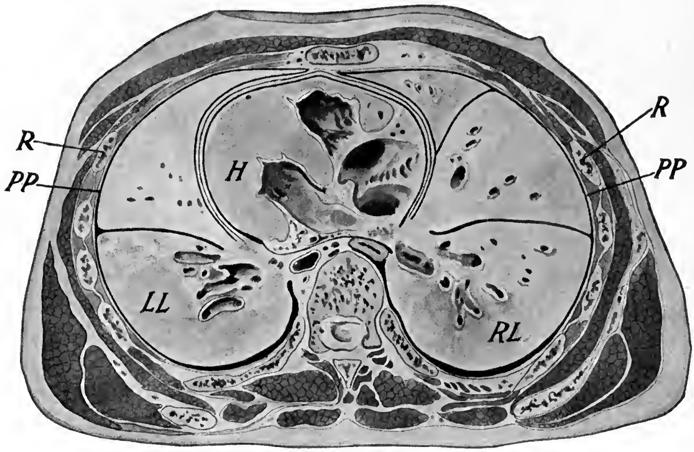


Fig. 89.—Transverse Section of Thorax to Show Relation of Lungs and Heart to Chest-wall.
H, Heart; *LL*, left lung; *RL*, right lung; *R*, rib; *PP*, parietal pleura.

the pleura. If the lungs have been injured, the emphysema is much more marked. It may spread over the entire body and endanger life if the rib has penetrated the lung (Fig. 90) and air is pumped into the tissues with every inspiration. If the lung is not fixed to the thoracic wall, a high degree of pneumothorax results. Fortunately this is a rare complication of fractured rib. Turner[22] only found it in 4 of 237 cases. If it is present, the ordinary signs of pneumothorax plus those due to displacement of the heart are present. The latter symptoms are cyanosis, dyspnea, and a rapid, weak pulse. A high temperature—104°–105° F.—is often present in cases of contusion or laceration of the lung.

Hemoptysis is also an important sign of lung involvement, but it is a very inconstant one. If there is free hemorrhage into the pleural cavity as the result of laceration of an intercostal artery or from a torn lung, the signs of hemothorax appear and may predominate over those of a pneumothorax. Intrathoracic hemorrhage may be suspected if there are symptoms of a severe internal hemorrhage, combined with those of a rapidly forming pleural effusion.[22] Rupture of the diaphragm or of the abdominal viscera must always be thought of in severe cases.

Prognosis.—This depends upon the age of the patient and the extent of the complications. In the aged, the treatment of a fracture of the rib may require confinement to bed for a week or more, and the outlook may become unfavorable on account of the development of a bronchitis or of a hypostatic pneumonia. In younger persons the prognosis of an

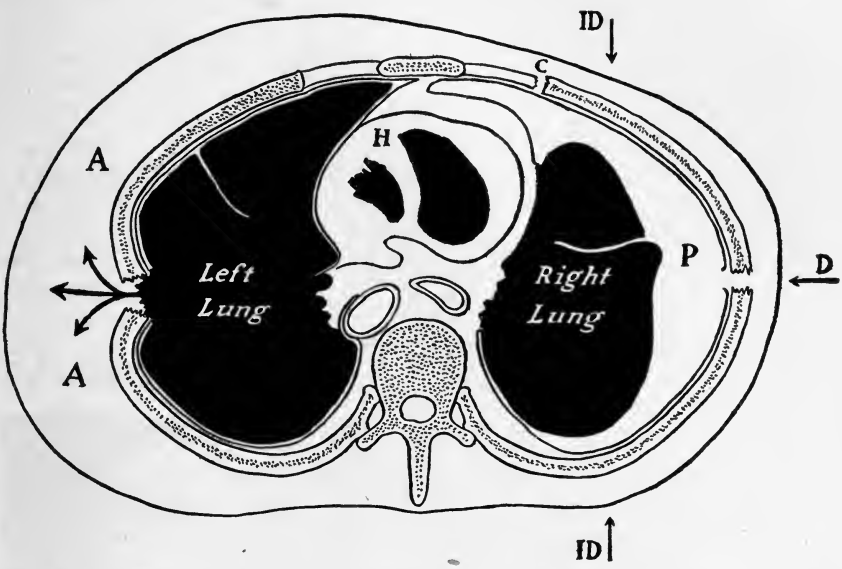


FIG. 90.—CROSS-SECTION OF THORAX (DIAGRAMMATIC) TO SHOW MODE OF PRODUCTION OF PNEUMOTHORAX OR HEMOTHORAX AND OF SUBCUTANEOUS EMPHYSEMA AS A RESULT OF FRACTURES OF THE RIBS.

ID, The arrow accompanying these letters shows the mode of action of indirect force in producing fracture of the ribs; D, mode of action of direct force in producing fracture of the ribs; P, pneumothorax as a result of fracture of the rib and laceration of the pleura on right side; A, extensive subcutaneous emphysema as a result of puncture of a lung by the sharp ends of a fractured rib fragment; the triple arrow shows the mode of egress of the air from the punctured lung into the subcutaneous tissues; H, cross-section of heart; C, fracture at costochondral junction without displacement.

uncomplicated case is good. The pain disappears within a week or ten days, and healing occurs in about four weeks. Failure of union is very rare. The callus is moderate and there is no danger of pressure upon the underlying thoracic viscera. Even in cases of multiple or of double fracture, union occurs with but little deformity. If complications exist, the prognosis will be directly dependent upon their severity. Emphysema, unless it be very severe, will slowly disappear. There is no danger of infection as the result of the presence of the air in the tissues. If the lung has been punctured (Fig. 90) by a broken rib and air is being pumped with every respiration into the tissues, death may occur in a short time unless relief be given (see Treatment).

If a pneumothorax exists, the prognosis will depend upon the degree of compression of the lungs and heart. This may become so excessive as to cause death. The same is true of a hemothorax. In addition the prognosis will depend upon the asepsis of the surgeon. If the pleural cavity becomes infected as the result of faulty aspiration (see Treatment),

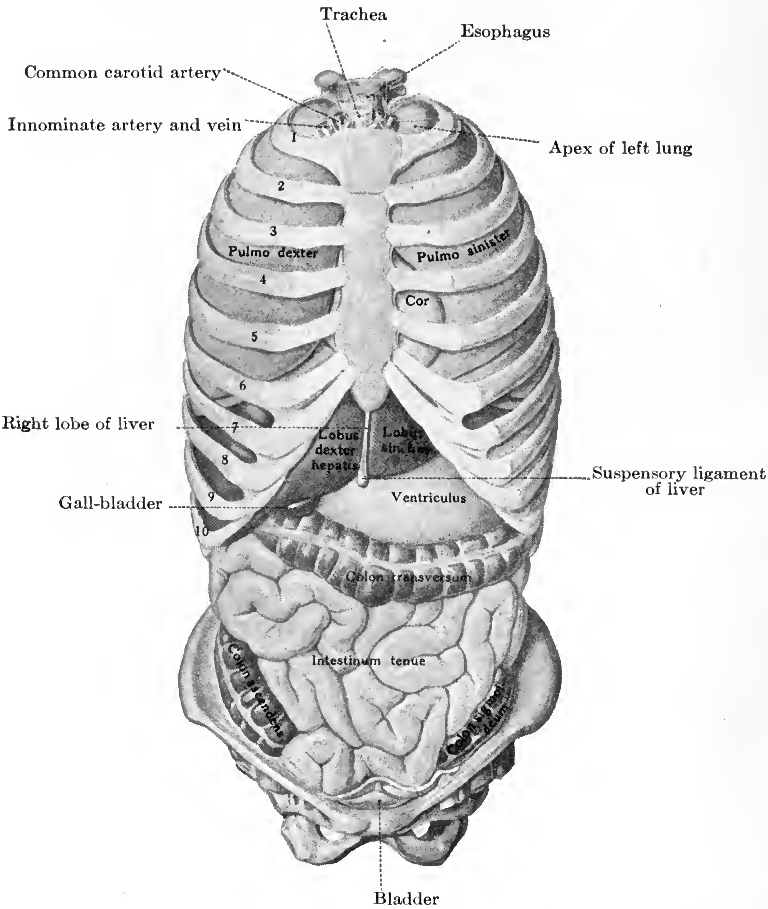


Fig. 91.—Anterior View of Relations of Thoracic and Abdominal Viscera to Thorax and Pelvis Respectively (Schultze and Stewart).

an empyema or a pyopneumothorax will result and greatly influence the outlook.

A condition of the heart known as *concussio cordis* may complicate a fracture of the ribs, causing a very rapid weak pulse for many weeks or even months, and it may seriously interfere with convalescence.

Blood and air in the pleural cavity are usually absorbed and leave only pleural adhesions. The prognosis of cases accompanied by severe injuries of the heart, lungs, diaphragm, liver, or spine is directly dependent upon the prognosis of these complications.

Traumatic pneumonia or pleuritis complicating fractures of the ribs is usually of such mild type as to influence the prognosis but little.

FIG. 92.—FIRST STEP IN APPLICATION OF STRIPS OF ADHESIVE PLASTER FOR FRACTURES OF THE RIBS.

Treatment.—The most useful dressing in the majority of cases is the application of three or more strips of zinc oxid plaster. Each strip should be three inches wide and long enough to extend beyond the middle line in front and behind.

They should all be ready before the first is applied. They are applied from below upward while the patient is asked to expel his breath. Each strip should overlap the previous one by two-thirds. They are applied at right angles to the long axis of the body. The lowest one should never be below the level of the umbilicus (Fig. 93).

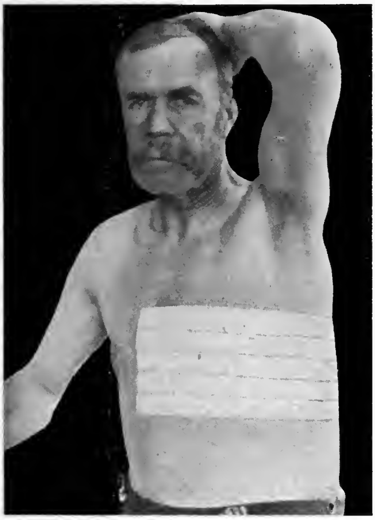


FIG. 93.—STRIPS OF ADHESIVE PLASTER APPLIED IN FRACTURES OF THE RIBS.

Each strip to cover two-thirds of the preceding one; patient being expected to expel his breath while strips are being applied. Every strip to extend to the median line in front and behind.

It is best, before applying the strips, to shave all hair from the chest and to cover the nipples with a few layers of gauze. The axilla should also be thoroughly cleansed and freely powdered. When it is impracticable to apply the adhesive strips, a fair amount of fixation can be secured by the use of a snugly fitting wide muslin binder.

Treatment of Complications.—*Emphysema,* unless it be so extensive as to threaten life, does not require any treatment. If great dyspnea and threatening asphyxia exist and the emphysema is increasing very rapidly, indicating the fixation of the lung by the end of a fragment, an incision has been made in several cases. The lung has been released, and an artificial pneumothorax produced, causing collapse of the lung.

Hemothorax requires no treatment unless there are signs of dangerous pressure upon the heart and opposite lung. If such symptoms as marked dyspnea, cyanosis, and rapid pulse exist, it is best to aspirate the blood with a Dieulafoy or Potain aspirator. If it reaccumulates, the aspiration can be repeated a number of times. Incision and drainage should never be performed, as the danger of infection is far greater than in aspiration. Autoinfection in a hemothorax is practically impossible, even though the lung be lacerated. If the signs of internal hemorrhage indicate a probable laceration of an intercostal artery or of the internal mammary artery, an attempt to ligate the bleeding vessel is indicated and justifiable.

Pneumothorax, if of sufficient extent to endanger life through pressure on the heart and lungs, is best treated by aspiration. The latter can be repeated at intervals. The treatment of a traumatic pneumonia or pleurisy does not differ from that of the same diseases when due to non-traumatic causes.

Fractures of the Costal Cartilages.—Only 80 cases of this form of injury have been reported. The most frequent location is at or near the junction with the ribs. In the majority of cases the outer or costal fragment is displaced in front of the inner end of the sternal fragment. The opposite may also occur. It is usually produced by a fall or blow upon the chest. The diagnosis and treatment are similar to those of fractures of the ribs. There are localized pain and the presence of the step-like deformity. Crepitus and abnormal mobility are seldom to be elicited.

INJURIES IN THE VICINITY OF THE SHOULDER-JOINT.

In the examination of a patient to ascertain the nature of an injury to the region of the shoulder, the following conditions must be thought of and eliminated by exclusion, in the order named:

1. Fractures of the clavicle (most often of the middle third).
2. Dislocation of the clavicle at its sternal or acromial ends (the latter is the most common).
3. Fractures of the scapula (most often of the acromion process).
4. Fractures of the upper end of the humerus (usually at the surgical neck).
5. Dislocation of the head of the humerus (the subcoracoid is the most frequent variety).
6. Fractures of the upper end of the humerus, combined with dislocation of the head.

The principal diagnostic features of the various fractures in this region are considered in the following pages. The dislocations are taken up in Chapter XXVI (see p. 377).

Fractures of the Clavicle.—About one-half of all the fractures of this bone occur in its middle third. Of the remaining half, about one-third are found at the junction of the outer and middle thirds of the bone. The fracture may be partial or complete, single or multiple, simple or compound. Incomplete or greenstick fractures occur in children as infractions. They often escape recognition until a callus has begun to form. The usual form of fracture is the simple complete. Compound fractures are very rare. The same is true of multiple and of comminuted fractures.

Fractures of the middle third, or at the junction of the outer and middle thirds, usually occur in adults.

The line of fracture is oblique in adults and transverse in children. The inner or sternal fragment is drawn upward by the sternocleidomastoid muscle, while the outer or acromial fragment points backward and is displaced inward in such a manner that it lies beneath the inner one. The cause of the displacement of the outer fragment is the weight of the arm causing the shoulder to fall forward and inward when the support usually given by the clavicle is removed. Fractures of the middle third are most frequently the result of indirect violence, such as a fall upon the shoulder or upon the outstretched hand or upon the elbow, the arm being extended and the muscles rigid. Fractures due to direct violence, such as a blow or a fall upon the clavicle or being run over, are quite uncommon.

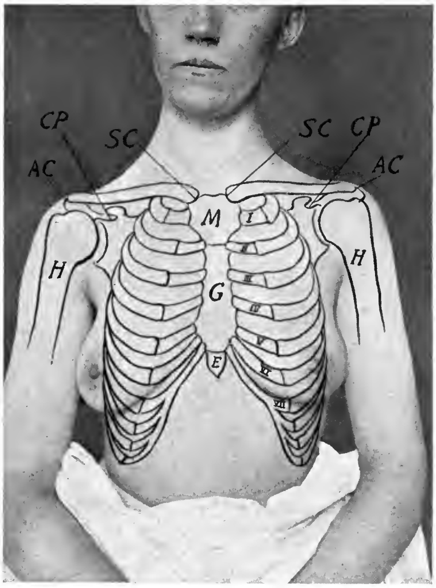


Fig. 94.—Relations of Bones of Thorax and of Shoulder-joints to Overlying Skin.
SC, Sternoclavicular joints; AC, acromioclavicular joints; CP, coracoid processes; H, humerus; M, manubrium; G, gladiolus; E, ensiform process.

Fractures of the Outer Third.—These are more often due to direct violence than those of the middle third. They are also oblique, but the amount of displacement varies, being quite marked in some cases and very slight in others. The fragments either form an angle with each other which points backward, or the outer fragment forms a right angle with the inner.

Fractures of the Inner Third.—These are comparatively rare. They are usually the result of muscular action, *i. e.*, of a violent contraction of the sternocleidomastoid muscle.

Diagnosis.—Fractures of the middle third are readily recognized when they are complete and the typical displacement of fragments is present. Upon passing the finger along the anterior or upper borders of the clavicle the projecting ends of the fragments are felt. When there is but little displacement, the seat of fracture can often be recognized by the presence of an angular deformity with the apex directed backward.

The other signs of fracture, such as crepitus and abnormal mobility, can be best found by alternately raising and lowering the arm while grasping it at the elbow, as shown in Fig. 95, and placing the other hand over the clavicle. At times it is necessary to draw the shoulder back to elicit crepitus. The diagnosis of those fractures which are complete but not associated with displacement, as well as of greenstick or incomplete fractures, is not as easy. In the latter there is great tenderness at the point of fracture, and pain on raising the arm voluntarily, referred to the seat of fracture. In many cases a slight elevation of the surface of the bone is present at the point of greatest tenderness.

Fig. 95.—Method of Examination for Fracture of the Clavicle.

The patient's left arm in the case of suspected fracture of the left clavicle is allowed to rest upon the left forearm of the examiner, so that the patient's arm as a whole can be raised or lowered as desired to determine a false point of motion, which the examining finger or fingers of the opposite or right hand of the surgeon can readily feel.

Multiple and comminuted fractures of the clavicle are quite rare and can be recognized by feeling the separate fragments and the use of the x-ray (Fig. 96).

Fractures near the sternal or clavicular ends of the clavicle are often associated with considerable displacement of the fragments, and may simulate a dislocation of the clavicle. In the case of a fracture there is distinct crepitus and the point at which abnormal mobility exists is situated close to the sternoclavicular or acromioclavicular joints respectively. The joints themselves can be found to be intact if one places the fingers over them while the arm is alternately raised and lowered. A familiarity with the anatomic relations, as gained by palpation during life on normal subjects, is of invaluable aid in the diagnosis of injuries of the bones and joints.

In case of doubt, especially if the injury is at the acromioclavicular joint, a skiagraph should be taken. In the greenstick fractures of children the callus is usually excessive in size for the first eight to twelve weeks, and then gradually disappears.

Prognosis.—In children, firm union occurs in fifteen to twenty days and in adults from twenty to forty days. In some cases it is impossible to completely reduce the deformity, but even a moderate degree of displacement of fragments does not interfere with perfect use of the shoulder. Non-union is very rare. The complications of fractures of the clavicle have been recently reviewed by Taylor.[1] He found 10 cases of injury to the nerves of the brachial plexus, 4 cases of injury of the subclavian vein, 5 cases of wounds of the subclavian artery, and 5 cases of penetration of the lung. When one considers the frequency of fractures of the clavicle, it will be seen that these complications are quite rare.

Treatment.—If little or no displacement exists, it is best to apply a Velpeau bandage. The turns of the muslin bandage can be most satisfactorily secured by passing over the completed bandage a few strips of

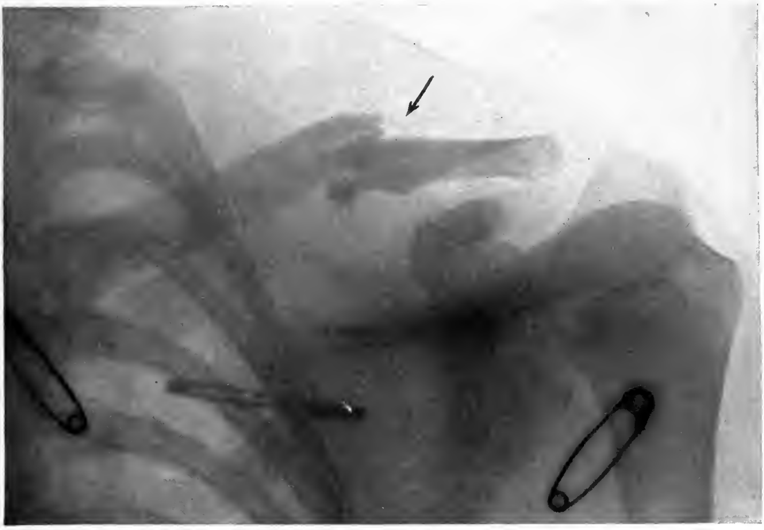


FIG. 96.—X-RAY OF FRACTURE OF CLAVICLE IN BOY OF EIGHTEEN.

The black arrow points to the seat of fracture. The inner fragment has been pulled upward and the outer fragment is displaced behind the inner one. The clear space between the outer end of the clavicle and the acromion process is due to the lack of ossification of the outer epiphysis of the former.

three-inch-wide adhesive plaster. The latter can be applied over the muslin in the manner shown in the Sayre dressing, thus serving the double purpose of fixation of the point of fracture and of the turns of the muslin bandage.

In all varieties of fracture (both complete and incomplete) in children the Sayre dressing will prove the most satisfactory.

In adults, if considerable displacement exists, one of three methods can be employed: (*a*) In stout individuals and in women with large breasts, the Sayre dressing is impracticable and an attempt should be made to use the *Velpeau dressing,* aided by the adhesive strips over the outside of the bandage. Before applying the dressing the shoulder must be pulled strongly backward and the elbow raised until the fragments are exactly in line.

(*b*) The *Sayre dressing* is the most satisfactory in the majority of cases. The objections to its use in the warm summer months have been largely overcome through the use of zinc oxid adhesive plaster. The various steps in the application of the Sayre dressing are shown in Figs. 97 to 101 inclusive.

The skin of the thorax should be shaved and thoroughly dried. The patient is best seated higher than upon an ordinary chair. The axilla and the bend of the elbow are washed with alcohol, freely dusted with talcum powder, and a small soft pad placed in them. A strip of muslin three inches wide is placed around the middle of the arm (Fig. 97) and sewn at the outer side. A second piece two inches square should be ready to place over the tip of the elbow, as well as a small pad of sheet-wadding to place over the point of fracture. In the majority of cases two strips of adhesive plaster suffice. It is advisable, however, to have three strips of three-inch-wide zinc oxid plaster ready. The first strip (Fig. 99) should be long enough to extend one and one-half times around the trunk, the second long enough to extend from the elbow of the injured side to the opposite shoulder and back again, and the third should extend from the elbow of the injured side over the shoulder of the same and back again.

Fig. 97.—Sayre's Method of Dressing in Fracture of the Clavicle.

1, Strip of muslin wrapped around arm and sewed so as to prevent it slipping off. Elbow and axilla padded with common cotton.

An assistant is instructed to raise the elbow and pull the shoulder far enough back to permit of accurate apposition of the fragments (Fig. 98). When this has been accomplished, the first strip is applied around the muslin on the arm in the manner shown in Fig. 98. It is then carried around the trunk and under the axilla of the opposite side, and across the front of the chest to the starting-point (Fig. 99). This strip pulls the shoulder back and fixes it to the side of the chest. The second strip is applied over the elbow, while the latter is well raised. It is separated from the olecranon by a small piece of linen or muslin. One end of the strip is carried around the back of the chest in an oblique manner to the acromion process of the opposite shoulder. The other end of the strip is carried over the extensor surface of the hand and forearm, which have been placed upon the chest, to the point mentioned. The two ends of the strip, if needed, are carried around the elbow to a little below the point of fracture, over the front and back of the chest respectively. This last strip permits direct pressure to be made over the ends of the fragments through the medium of the soft cotton pad, but seldom is needed.

By the end of the third week the Sayre dressing can be removed and the arm kept in a sling for one week more. The atrophy of the deltoid and stiffness of the shoulder-joint can be readily overcome by the use of massage and by active and passive movements after the fourth week.

Fig. 98.—Second Step in Sayre Dressing. The arm has been raised; the shoulder is steadied while the arm itself is pulled backward by the first strip of adhesive plaster, which passes around the chest and is attached to the arm again at the starting-point, as shown in Fig. 99.

Fig. 99.—Application of First Strip of Adhesive Plaster in Sayre Dressing.

(*c*) *Operative Measures.*—If there is a tendency to the recurrence of displacement in spite of the ordinary fixation dressings, suture of the fragments gives very satisfactory results. An incision is made under the strictest aseptic precautions, the ends exposed and drilled. The best suture material is kangaroo tendon. It is rarely necessary to use silver or bronze aluminum wire.

After the wound has been sutured and a collodion dressing applied, an ordinary Velpeau bandage, reinforced with starch bandages or a few turns of a plaster-of-Paris bandage or adhesive plaster suffices.

Fractures of the Scapula.—Fractures of this bone may occur either through the body, inferior and superior angles, spine, acromion, coracoid, surgical neck, and glenoid cavity. Of these, all except fractures of the body, acromion, and spine are so rare as to be of little importance clinically. Fractures of the body may be suspected from the history of a blow or other direct violence over the scapular region, followed by pain localized over the body of the scapula and increased by any movement of the arm. The outline of the bone can be felt to be irregular, and, by

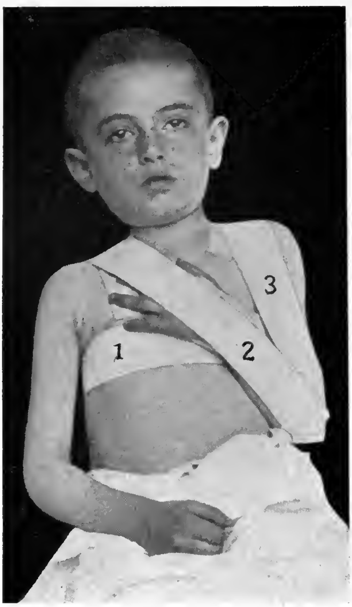


Fig. 100.—View of Sayre Dressing Completed.

Strip No. 1 is fastened around the chest and binds arm to side. Strip No. 2 passes over olecranon process on injured side, across back, as shown in Fig 101, the two ends meeting over the clavicle of the sound side. The olecranon region itself should be protected by a small strip of muslin bandage against the decubitus. The third strip, No. 3, is not necessary unless there is a great tendency to displacement of the fragments. This is passed over the clavicle of the injured side and around the elbow, pressure being made directly over the point of fracture by means of a small pad of cotton.

Fig. 101.—Posterior View of Sayre Dressing in Fracture of the Clavicle.

1, 2, 3, As described in Fig. 100; 4, muslin bandage surrounding arm on injured side, so as to prevent undue pressure from strip No. 1 of Sayre dressing.

grasping the lower angle, one can obtain crepitus and abnormal mobility (Fig. 102). In many cases this is either difficult or impossible on account of the pain and swelling, so that reliance must be placed on feeling an irregularity and the presence of severe pain on pressure and movement.

Fractures of the acromion process, like those of the body of the bone, are very difficult to recognize by palpation. The use of the x-ray has been of great aid in the diagnosis of these fractures. On passing the finger backward from the tip of the process one can at times feel a depression corresponding to the displacement of the fragments. Crepitus and abnormal mobility are obtained by alternately raising and lowering the arm grasped at the elbow, while the finger is placed over the acromion process. There is usually inability to raise the arm.

The most frequent locations of these fractures are either at the base or tip of the acromion process. Fractures of the surgical neck of the scapula are very rare. They simulate dislocations of the shoulder on account of the dropping of the humerus, with marked concavity below the acromion process (Fig. 291). When the arm is raised, the latter deformity disappears, the manipulation being accompanied by crepitus. An x-ray will readily clear up the diagnosis.

Treatment.—The scapula can best be immobilized by raising the arm as in fractures of the clavicle and by supporting the elbow. At the same time the arm is fixed to the side of the chest. These objects are best accomplished through the use of a Velpeau bandage reinforced by adhesive plaster or plaster-of-Paris or by the Sayre dressing. If the latter, it should be applied with care, plenty of sheet-wadding being placed over the acromion and body of the scapula.

Fig. 102.—Method of Grasping Scapula to Determine Fracture of Same.

Fractures of Upper End of Humerus.—The various forms and locations of fractures at the upper end of the humerus are:

(*a*) Fractures of the anatomic neck alone or associated with fractures of the tuberosities.

(*b*) Fractures of the greater or lesser tuberosities.

(*c*) Epiphyseal separation.

(*d*) Fractures of the surgical neck with or without impaction.

(*e*) Dislocation of the head of the humerus combined with any of the fractures just named.

(*a*) *Fractures of the Anatomic Neck* (Fig. 103).—As an isolated injury, this form of fracture of the upper end of the humerus is extremely rare, only a few cases having been reported. It is usually associated with fracture through the tuberosities in elderly people, occurring as the result of direct violence, such as a fall upon the shoulder. It is more frequently combined with dislocation of the head of the bone than are fractures of the surgical neck. Not infrequently there is firm impaction of the head into the shaft. The head of the bone may be completely detached and lie free in the joint cavity, or be displaced into the axilla. The symptoms are so indistinct that it can seldom be distinguished from a fracture of the surgical neck except by an x-ray examination. Marked swelling and pain upon rotation or grasping the head are the most prominent symptoms. It is very difficult, and in many cases impossible, to obtain either crepitus or abnormal mobility.

(*b*) *Fractures of the Tuberosities.*—These are also comparatively rare as isolated injuries. They usually accompany a forward dislocation of the head or a fracture of the anatomic neck. Nieszytka[24] has recently called attention to the fact that isolated fracture of the greater tuberosity is frequently found upon *x*-ray examination in cases previously diagnosed as sprains or contusions of the shoulder. The cause is usually a direct violence, such as a fall or blow upon the shoulder. The fragments may be caught between the acromion and the head of the humerus, causing locking of the joint. The diagnosis of fracture of the greater tuberosity is made from the presence of localized pain on pressure and external rotation. The latter movement is usually absent. If the arm is abducted while the tuberosities are grasped, crepitus can at times be obtained. The examination with the *x*-ray is the most certain method of making a diagnosis. Keen[1] has recently reported a case in which he operated by a vertical incision through the deltoid, brought the broken fragment into place, and nailed it there by two disinfected wire nails, with a good result. Only a few cases of fracture of the lesser tuberosity have been reported as an isolated injury. It is usually an accompaniment of a dislocation of the shoulder or of a fracture of the greater tuberosity, or of those fractures of the anatomic neck in which the shaft is impacted between the head and the tuberosities. The best example of its occurrence as an isolated injury is the case reported by Lorenz,[25] which followed forcible outward rotation of the arm. When the patient was examined sixteen months after the injury, internal rotation was impossible. Upon palpation a sharp edge of bone was felt where the lesser tuberosity had been located, and a loose piece of bone could be palpated below the coracoid process.

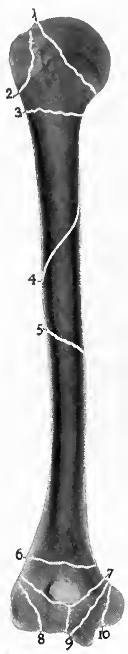


FIG. 103.—LOCATIONS OF MOST FREQUENT FRACTURES OF THE HUMERUS.

1, Of the anatomic neck; 2, of the greater tuberosity; 3, of the surgical neck; 4, spiral fracture of shaft; 5, oblique of shaft; 6, supracondyloid; 7, T or Y-shaped, at lower end, extending into joint; 8, of external condyle; 9, of internal condyle; 10, of internal epicondyle.

(*c*) *Epiphyseal Separation.*—This occurs most frequently between the ages of nine and seventeen, although cases have been recorded from the time of birth to the age of twenty-five. As a rule, the injury is the result of direct violence, according to Linser[26] and Poland,[27] usually a fall upon the shoulder. Indirect violence, such as an excessive abduction of the arm or outward rotation of the arm combined with traction, is a much less frequent cause. In some cases there is no displacement. In many, however, the lower fragment or diaphysis is displaced forward. In a few cases the diaphysis is pulled upward and inward to such an extent as to lie beneath the skin, as in fractures of the surgical neck in children (Figs. 108, 109).

The diagnosis in cases without displacement is very difficult. It can be made only by the localized pain on pressure, or by the pain and soft crepitus when the humerus is rotated. There is also abnormal mobility at some point below the head, and the latter does not move when the shaft is rotated.

In some cases the displacement does not occur at the time of the accident, but after a few days. In this class of cases, and in those in which displacement occurs at once, the diagnosis can be made by palpation if the swelling is not too great. If it is, an x-ray examination should be made as soon as possible. One can feel the normal convexity of the shoulder, due to the fact that the head is still in the glenoid cavity, thus distinguishing it from a dislocation. The upper end of the diaphysis can be felt below the coracoid process. It rotates with the shaft and can be rendered more prominent by raising the shoulder. Upon manipulation a soft cartilaginous crepitus can be felt. It should not be sought for too vigorously without the use of an anesthetic.

FIG. 104.—METHOD OF EXAMINATION OF FRACTURES OF THE SURGICAL NECK OF THE HUMERUS.

The left hand grasps the arm close to the point of fracture in the case of the right arm, and vice versâ in the case of the left arm, while the forearm of the patient is allowed to rest upon the outstretched palm of the examiner. By carrying the forearm and lower fragment alternately away from and toward the body, the false point of motion and crepitus can be readily elicited.

In the differential diagnosis one must consider: (a) dislocations of the humerus forward and (b) fracture of the surgical neck. Epiphyseal separations can occur only at a time of life when dislocations are very rare, those of the shoulder-joint being extremely infrequent in children (Poland). The end of the diaphysis, if displaced below the coracoid, is convex and rather smooth, and may easily be mistaken for the head. The end of the diaphysis is never as smooth or rounded as the head, and it has an abrupt anterior ledge situated farther down and smaller than the normal head. The skin is held very firmly over the projection in an epiphyseal separation, but is not so in a dislocation.

In addition the shoulder retains its general rotundity and there is no depression immediately below the acromion, as in a dislocation. The head of the bone, often distinctly felt in the socket, is one of the best distinguished signs. The fragments are not easily maintained in position after reduction. In dislocation after reduction the parts usually maintain their position, and the movements are free again. From fracture of the surgical neck the differentiation is very difficult and often impossible until an x-ray has been taken (Fig. 109). We have to rely upon the age. In youth a direct injury to the shoulder is more likely to be followed by epiphyseal separation. The angular, convex, or smooth end of the diaphysis which one palpates in complete displacement is unlike the sharp projection of a fracture, which is situated somewhat lower than in a separation. The muffled crepitus of separation, when present, is characteristic.

(*d*) *Fractures of the Surgical Neck.*—These include all fractures in the

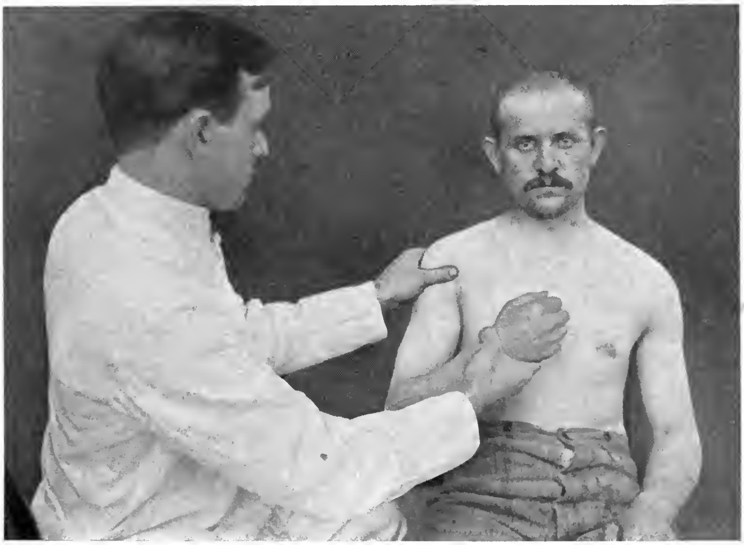


FIG. 105.—METHOD OF EXAMINATION TO BE EMPLOYED IN MAKING A DIFFERENTIAL DIAGNOSIS BETWEEN DISLOCATION OF THE SHOULDER-JOINT AND FRACTURE OF THE ANATOMIC OR SURGICAL NECK OF THE HUMERUS.

This illustration shows the manner of examining the head of the humerus in order to determine whether it has its normal range of rotation, thus aiding in ascertaining whether the head of the humerus lies in the glenoid cavity. The method consists in grasping the forearm of the patient close to the wrist with one hand, while the head of the humerus is held between the thumb in front and the remaining fingers behind, *i. e.*, along the anterior and posterior borders respectively of the deltoid muscle.

upper fourth of the bone below the epiphyseal line. On account of the atrophy of the cortex at this point as age advances, it most often occurs in elderly people. The most common cause is direct violence, such as a fall or blow upon the upper part of the arm. This is especially the case in old age. In younger persons it occurs frequently after falls upon the hand or upon the abducted elbow, *i. e.*, by indirect violence. The line of fracture is either transverse or oblique. The former are often impacted (Fig. 110), owing to the fact that the shaft becomes wedged a variable distance into the head. The entire width of the shaft or only a portion of the cortex may be impacted.

In the non-impacted form the most frequent mode of displacement is for the upper fragment to be abducted and rotated outward or it is rotated inward, upward, and forward. The former is the usual form of displacement of the upper fragment. The two fragments may be completely separated, owing to the fact that the pectoralis major and latissimus dorsi pull the lower fragment inward and upward. Injury of the adjacent vessels and nerves is very rare. Angerer (quoted by Hoffa[1])

FIG. 106.—METHOD OF DETERMINING THE DISTANCE BETWEEN THE ACROMION PROCESS (*A–P*) AND THE EXTERNAL CONDYLE OF THE HUMERUS (*E–B*), BY MEANS OF A STEEL TAPE-MEASURE.

This method is often used in order to compare the humerus of one side to that of the other, and also for the purpose of determining the distance between these two points in the diagnosis of dislocations of the head of the humerus or fractures of the surgical neck.

reports a case in which gangrene of the arm resulted from compression of the axillary vessels by the sharp lower fragment.

Diagnosis.—The diagnosis is easy in the non-impacted cases, especially if the displacement is complete. As in the cases of epiphyseal separation, the diagnosis is difficult or easy according to the degree of displacement. In both instances the head of the bone, by grasping it between the fingers, is found to lie in the glenoid cavity. On rotating the shaft in cases without displacement the head fails to participate in the movement of the shaft

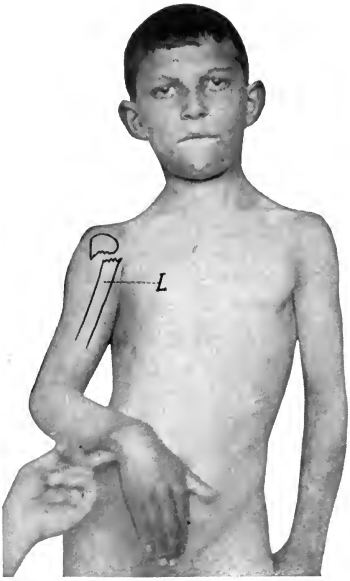


Fig. 107.—Frequent Mode of Displacement of Fractures of the Surgical Neck or of the Humerus, or of Separation of the Upper Epiphysis in Children.

L, Lower fragment (shaft), displaced inward and forward. Compare with Fig. 108.

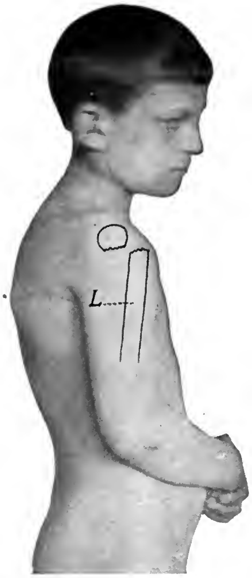


Fig. 108.—Side View of a Case of a Fracture of the Surgical Neck of the Humerus.

Showing lower fragment displaced upward and forward in boy of ten. Compare with Fig. 107.

Fig. 109.—X-ray of Fracture of Surgical Neck of Humerus in a Boy Ten Years of Age.

The arrow points to the line of fracture. The lower fragment, FD, has been pulled upward and outward through the action of the deltoid muscle, so that it forms, as is frequently the case, an angle with the upper end of the bone; FE, upper epiphysis of humerus on injured side. The clear line just below it and separating it from the shaft or diaphysis is due to the fact that the epiphyseal cartilage does not cast a shadow. NE, Epiphysis on normal side; ND, diaphysis or shaft on normal side.

and there are pain, crepitus, and abnormal mobility at the point of fracture.

If impaction of the fragments exists, all these signs are absent and the diagnosis can only be made from the history of the mode of injury, the presence of localized pain upon rotation, loss of function of the arm, and an x-ray (Fig. 110). In cases with moderate or more marked displacement the ends of the fragments and their relation to each other can be felt in thin subjects by following the shaft upward. Abnormal mobility and crepitus are usually quite easily elicited. There is often a change in

FIG. 110.—x-RAY OF IMPACTED FRACTURE OF SURGICAL NECK OF THE HUMERUS IN A MAN OF THIRTY-FIVE.
The outlines of the line of fracture were traced in ink upon the x-ray. The shaft of the bone has become impacted into the head.

the axis of the arm (Fig. 291), as in dislocation, but the presence of the head in the glenoid cavity and the normal contour or convexity of the shoulder will exclude dislocation. The coexistence of fracture of the surgical neck and dislocation of the shoulder are referred to later. The differential diagnosis of fractures of the surgical neck and other forms of injury in the vicinity of the shoulder are given in the following table.

DIFFERENTIAL DIAGNOSIS OF INJURIES OF THE SHOULDER (Fig. 290).

	Abnormal Prominences.	Convexity of Shoulder.	Position of Head.	Axis and Length of Arm.	Crepitus, Abnormal Mobility, etc.
1. Sprain.	None.	Unchanged.	Rotates in joint.	Unchanged.	Absent.
2. Dislocation.	Prominence above acromion.	Unchanged.	Rotates in joint.	Axis changed and arm shorter.	Outer end of clavicle shows abnormal mobility above acromion.
3. Fracture of acromion process.	None unless marked displacement.	Acromion lower, otherwise unchanged.	Rotates in joint.	Unchanged.	Crepitus and abnormal mobility above acromion.
4. Fracture of spine of scapula (rare).	Acromion very prominent.	Depression beneath acromion.	Head felt in axilla but rotates in joint and can be raised.	Axis unchanged but arm apparently longer.	Distinct crepitus and abnormal mobility.
5. Fracture of upper end of humerus (surgical neck or epiphysis).	Prominence of upper end of shaft below coracoid or acromion.	Shoulder somewhat flatter, according to degrees of displacement.	Head in glenoid cavity, does not rotate with shaft.	Axis changed more internal, arm shorter.	Unless impacted, get distinct crepitus and abnormal mobility in adults. Less marked in children.
6. Dislocation of humerus.	Acromion prominent.	Depression or flattening beneath acromion.	Head felt below coracoid process or in axilla.	Axis changed, length increased.	Head fixed, adduction impossible. Only mobile if tuberosities broken.

Treatment.—(*a*) *Fracture of the anatomic neck* is best treated by a molded plaster-of-Paris splint such as is shown in Fig. 112, aided by a liberal pad of sheet-wadding or common cotton placed in the axilla. If it is impracticable to use the molded splint, a simple Velpeau bandage with an axillary pad suffices.

(*b*) *Fracture through the tuberosities* combined with a fracture of the anatomic neck requires the same treatment as that of the latter lesion alone. An isolated fracture of the greater tuberosity requires immobilization, with as much outward rotation of the arm as possible. An isolated fracture of the lesser tuberosity should, on the other hand, be treated with immobilization and inward rotation of the arm.

(*c*) *Separation of the Epiphysis.*—As in the treatment of all fractures of the upper end of the humerus, perfect reduction of the fragments can be accomplished if an anesthetic be given. This is especially true of epiphyseal separation where the growth of the humerus may readily cease or be retarded unless the apposition is fairly exact. The reduction is best accomplished in simple cases, under an anesthetic, by having an assistant make traction upon the elbow while the surgeon presses the upper end of the lower fragment backward and outward. Separation with more or less complete displacement forward may be one of the most difficult injuries to treat at the upper end of the humerus, according to Poland.

It is reduced by extension and abduction of the arm, assisted by direct pressure upon the displaced diaphysis. Great difficulty may be experienced on account of the locking of the fragments and the small size of the upper fragment.

When the displacement tends to recur constantly, permanent extension after the method of Bardenheuer (Fig. 113) should be employed. It is impossible in some cases to effect a reduction. If such be the case, an incision is indicated. In a few cases it will be necessary to resect the end of the diaphysis before reduction can be effected. In the majority, however, this will not be necessary. If the displacement recurs, the two fragments should be united by wire or, better, by some absorbable material like kangaroo tendon.

(*d*) *Fracture of the Surgical Neck.*—The questions which arise in the treatment of fractures at this point are, first, does much displacement exist? second, is the fracture impacted or non-impacted?

In cases with but little displacement, whether the fracture be an impacted or non-impacted one, any attempt at reduction is superfluous. In impacted fractures in which, for example, the tuberosities or the head or both are considerably displaced by the lower fragment which is wedged between them, it is best to attempt to loosen the fragments by abducting the arm gradually so as to keep the fragments in apposition.

In non-impacted fractures with considerable displacement the arm should be strongly abducted, while traction is made upon the elbow by an assistant. The lower fragment is thus brought into the axis of the upper.

If reduction is impossible under an anesthetic by traction in an abducted position, one of two methods remain: The first is to make an incision over the seat of fracture and effect a reduction under guidance of the eye and finger. The second method is to try the extension treatment of Bardenheuer.

Through traction upon the lower fragment in an abducted position it is gradually brought into line with the upper. This extension is left in place for about three weeks.

An equally satisfactory method is that shown in Fig. 113, in which the extension is made in a downward direction during the day and over the side of the bed at night.

The immobilization of a fracture of the surgical neck or of an epiphyseal separation after apposition of the fragments has been secured, is best accomplished by some form of splint which will bind the arm to the side of the chest.

The axilla and the entire arm should be shaved and freely powdered. The arm, from the middle of the hand to the shoulder, is bandaged with a flannel bandage. A triangle is made either of cardboard or, better, as shown in Fig. 111, of poplar one-eighth of an inch thick. This form of a splint is less irksome than a Middeldorpf triangle. The inside of this triangular splint is filled with ordinary cotton, and the entire splint covered with muslin. The two sides of the triangle should be long enough to extend from the apex of the axilla to the level of the internal condyle (Fig. 111).

The splint is fixed to the body by adhesive plaster (Fig. 111) or by a muslin strap passing over the opposite shoulder. The object of this triangular splint is to fill in the gap between the body and the arm and thus prevent a tilting outward of the lower fragment.

Pressure is exerted upon the shoulder either by a perforated metal or felt shoulder-cap or, better still, by the use of a molded plaster-of-Paris splint (Fig. 112).

In the case of fractures of the surgical neck, of epiphyseal separation, or of fractures of the shaft (see below), such a splint should extend from the middle of the clavicle to the hand, as shown in Fig. 112.

If a molded splint cannot be employed, the application of a Velpeau bandage, covered by a few turns of plaster-of-Paris or by some strips of adhesive plaster, will often yield equally good results.

After-treatment.—Whichever method of fixation is employed, *i. e.*, the use of splints or of extension, firm union will usually be present at the end of the fourth week.

The fingers should always be left free, and the patient encouraged to move them frequently. At the end of the fourth week all splints may be omitted. Massage, active and passive motions, can now be systematically begun, as outlined on p. 136.

The arm should be carried in a sling for a week after the splints or extension have been removed. If the deltoid muscle is greatly atrophied, the use of hot applications and of faradic electricity and massage will greatly hasten its restoration to function. The daily use of the gymnastic apparatus shown in Fig. 75 is especially to be recommended for this class of fractures to prevent ankylosis.

(*e*) The treatment of *fractures of the upper end of the humerus associated with dislocations of the head* is considered in the chapter upon Dislocations.

Fractures of the Shaft of the Humerus.—In this are included all fractures between the insertion of the deltoid above and the upper end of the supracondyloid ridges below.

The causes of fracture are: (*a*) Direct violence, such as a blow upon the arm or being run over; (*b*) indirect violence, *e. g.*, a fall upon the elbow or outstretched hand; (*c*) muscular action. This last-named cause plays a greater rôle in the etiology of fractures of the shaft of the humerus than in any other long bone. The fractures are either complete or incomplete. The latter are very rare, and usually occur in rachitic children. In addition to transverse and oblique lines of fractures, a third variety of complete fractures occurs quite frequently, viz., a spiral fracture (p. 78). As in the case of the shaft of all long bones, the fracture may be open (compound) or closed (simple), or it may be single, multiple, or comminuted. Oblique and spiral fractures are most apt to follow indirect force.

The displacement varies according to the seat of the fracture. In those which lie in the upper third of the shaft, the upper fragment is pulled inward by the pectoralis major, and the lower one is pulled upward by the deltoid. In fractures of the middle or lower third, the deltoid pulls the upper fragment forward and outward, while the triceps pulls the lower one upward and backward. There is but little tendency to displacement in fractures of the middle third. The most important complications are injuries of the vessels and nerves which lie in close relation to the bone.

The symptoms of these complications have already been given. In injury to the brachial artery there will be loss of pulsation at the wrist, pallor, coldness, and later signs of gangrene in the hand and forearm. The nerve most often involved is the musculospiral. The symptoms either appear at the time of injury or later, through inclusion of the nerve in the callus (Fig. 50). In 68 cases collected by Blenke,[28] the musculospiral paralysis was primary in 20, while it was secondary in 35 cases. In 56.5 per cent. of the cases the fracture was in the middle third, and in 41.3 per cent. in the lower third of the bone. A smaller number of cases of injury to the median and ulnar nerves have been reported, the fracture usually being in the lower third.

In addition to the primary and secondary forms just referred to, Fessler[29] has described an intermediate form of nerve paralysis which appears from hours to days after a fracture, due to overstretching over the dislocated fragment or its injury in the healing process. The diagnosis can be readily made by careful manipulation of the arm (Fig. 104). The ordinary signs of fracture, such as crepitus, abnormal mobility, loss of function, and pain, are all well marked. If displacement exists, this can often be seen or palpated. A skiagraph should be made, if possible, in every case both before and after reduction. Attention is again called to the possibility of the x-ray exaggerating the degree of displacement.

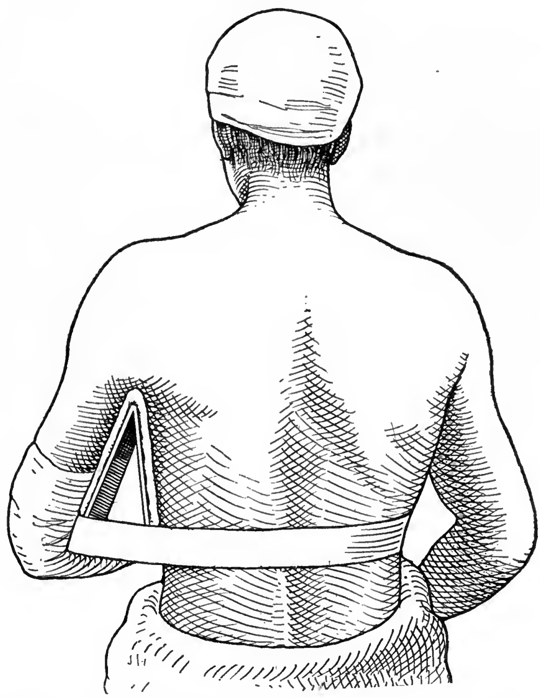


Fig. 111.—Triangular Splint in Fractures of Humerus (Posterior View).

The splint is held in place by a strip of adhesive plaster passing around the body. The sides and base of the triangular splint are made of thin wood. The sides should be a little wider than the arm, and are liberally padded.

A careful examination should be made both at the time of injury and during the period of healing for evidences of injury to the vessels and nerves. It should be the routine practice in every case to make a careful examination as to sensation and muscular action. The most prominent symptom of musculospiral involvement is drop-wrist.

Treatment.—Ordinarily a simple fracture of the humerus in which the dislocation of fragments has been corrected will be united in three to four weeks in children, and four to six weeks in adults. Delayed union and non-union occur with greater frequency here than in almost any other bone. This is not due to interposition of muscle or periosteum, as was formerly supposed to be the case, but to too early movements and lack of proper fixation. The reduction should be carried out under an anesthetic, if possible, especially in oblique and spiral fractures, in which the tendency to recurrence of the displacement is greater than in the transverse variety. Traction should be made by firmly grasping the lower end of the humerus by the flexed elbow. After reduction the external condyle and the acromion process should be in a line.

The treatment of fractures of the shaft of the humerus is almost identical with that of the surgical neck. Extension is rarely necessary, except in oblique fractures with great tendency to recurrence of displacement. One of the most convenient methods of treatment when reduction is perfect is the triangular splint shown in Fig. 111, with a molded plaster splint covering the outer side of the shoulder, arm, and forearm. If the plaster splint is not employed, the triangular splint, as described, can be used, and a second flexible wooden or heavy cardboard splint applied over the outer side of the arm and fixed to the arm by adhesive plaster. Over these a Velpeau bandage is applied.

FIG. 112.—MOLDED PLASTER-OF-PARIS SPLINT FOR USE IN THE TREATMENT OF FRACTURES OF THE SHAFT OF THE HUMERUS.

Spiral fractures are not uncommon; they are difficult to reduce and to retain in proper position. Whenever it is impossible to reduce the fragments or to maintain them in position, an operation is indicated. The use of the Middeldorpf triangle has been warmly recommended in the treatment of oblique and spiral fractures of the shaft. It can be combined with the use of extension.

Cases of delayed union or of non-union are treated in the manner described on p. 137.

In regard to paralysis from injury to the musculospiral nerve the safest course to pursue is to wait a few weeks in a primary case. If function has not returned at the end of four weeks, the nerve should be explored and isolated. If it is torn, it should be sutured. It is impossible to distinguish clinically between compression of the nerve or separation of its continuity. If the paralysis is intermediate (p. 101) or secondary, the nerve should be cut down upon and freed. If the gap between the ends of the nerve is so great that they cannot be approximated, resection of the humerus is indicated.

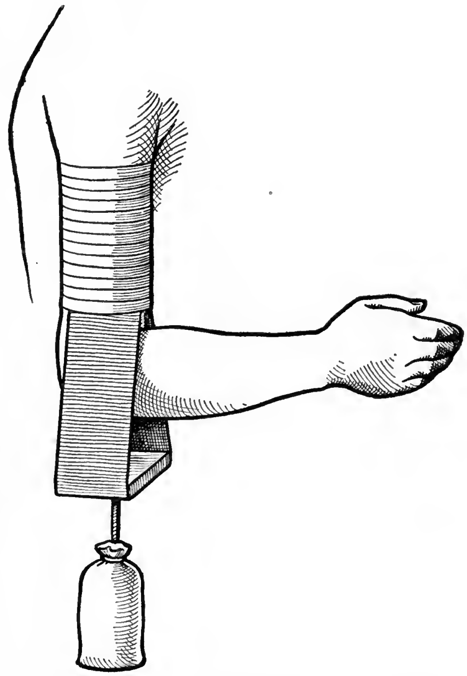


FIG. 113.—EXTENSION APPARATUS FOR FRACTURES OF SHAFT OF HUMERUS.

The strips of adhesive plaster are applied to the outer and inner aspects of the arm and a weight of three pounds used.

INJURIES IN THE VICINITY OF THE ELBOW-JOINT.

In the examination of a person suffering from an injury of the elbow-joint the following possible lesions must be thought of, and one after the other excluded by a systematic examination, combined, if required, with the use of the x-ray.

1. *Fractures of Lower End of Humerus.*
   - (*a*) Supracondyloid fracture (more or less transverse of the shaft above the condyles).
   - (*b*) T- or Y- shaped fractures.
   - (*c*) Epiphyseal separation.
   - (*d*) Fractures of the external or internal condyles and epicondyles.
2. *Lesions of the Radius and Ulna.*
   - (*a*) Dislocation backward of the radius and ulna.
   - (*b*) Fracture of the upper third of the ulna, with or without dislocation forward of the radius.
   - (*c*) Dislocation forward of the upper end of the radius.
   - (*d*) Fracture of the olecranon process of the ulna.
   - (*e*) Fracture of the neck or head of the radius.
   - (*f*) Subluxation of the head of the radius.
3. *Simple Sprains of the Elbow.*

In the majority of cases swelling occurs so rapidly after injuries of the elbow that palpation is difficult. In children especially, the administration of an anesthetic is advisable in order to make a diagnosis.

Familiarity with the surface anatomy of the region of the elbow will be of great aid in an examination for possible injury. The more important normal landmarks are: (*a*) The two condyles of the humerus and the tip of the olecranon process form an equilateral triangle when the arm is flexed to a right angle. When the arm is extended, they lie in a straight line (Fig. 115). (*b*) The head of the radius can be felt to rotate below the external condyle of the humerus (Fig. 116). (*c*) The angle with its apex

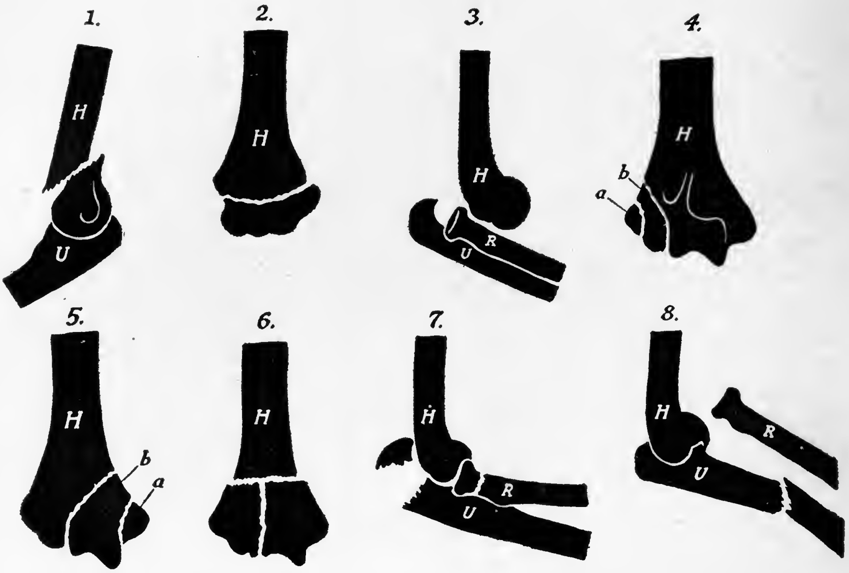


Fig. 114.—Most Frequent Forms of Injury of the Bones Comprising the Elbow-joint. *H*, Humerus; *R*, radius; *U*, ulna. 1, Supracondyloid fracture of humerus; 2, epiphyseal separation of the lower end of humerus; 3, backward dislocation of both bones of forearm; 4, fracture of internal epicondyle (*a*) and of internal condyle itself (*b*); 5, fracture of external epicondyle (*a*) and of external condyle (*b*); 6, T-shaped fracture of lower end of humerus; 7, fracture of olecranon and of neck of radius; 8, fracture at junction of upper and middle thirds of the shaft of the ulna, combined with forward dislocation of head of radius.

inward which is formed by the radius and ulna with the humerus when the hand and forearm are held in a supinated position is known as the *carrying angle.*

If the two condyles of the humerus lie in their normal relation to the olecranon process, as determined by palpation and mensuration, this will exclude a dislocation of both bones of the forearm, a fracture of either condyle, and a fracture of the olecranon process.

If the head of the radius can be felt to rotate in its normal position (Fig. 116), this will exclude a fracture of the neck or head of the radius and a dislocation of the radius.

Fig. 115.—Method of Determining the Relation of the Three Bony Points at the Back of the Elbow in Examinations for Fractures or Dislocations of the Bones Which Form the Elbow-joint.

In the case of an examination of the left elbow, as shown here, the patient's left forearm is allowed to rest upon the left forearm of the examiner, while the latter's right hand supports the elbow in such a manner that the thumb rests upon the external condyle, the middle finger upon the internal condyle, and the index-finger upon the tip of the olecranon. The relation of these three points is shown in the illustration when the elbow is flexed, that is, the tip of the olecranon lies a little below the dotted line joining the two condyles. When the arm is extended, the tip of the olecranon lies either in this line or above it.

Fig. 116.—Method of Palpation of Head of Radius.

In examining the head of the radius of the left arm, as shown in the illustration, the surgeon grasps the patient's hand with his own left hand as though he were shaking hands. The surgeon then grasps the head of the radius (which is to be found just beneath the external condyle of the humerus) between the thumb and index-finger of the right hand. The patient's forearm is alternately supinated and pronated, while the surgeon's right hand can feel the rotation of the head of the radius. On the right side the hands of the examiner are simply reversed.

Fractures of the Lower End of the Humerus.—(*a*) *Supracondyloid fracture* occurs more often in early life than at a later period. Kocher has shown that there are two varieties, viz., an extension and a flexion fracture. The *extension variety* is the more frequent and follows a fall upon the outstretched hand or a twisting of the arm. The line of fracture is oblique from behind downward and forward. The upper fragment is displaced downward and forward, so that its sharp end is often fixed in the skin in front of the elbow or actually penetrates it. This variety is also apt to be accompanied by laceration of the brachial artery and by severing or compression of the radial, median, and ulnar nerves. Savariand[30] found 4 such cases of injury of these nerves. Bérard[31] has reported 7 similar cases, 2 in recent and 5 in badly united fractures. In 3 there was

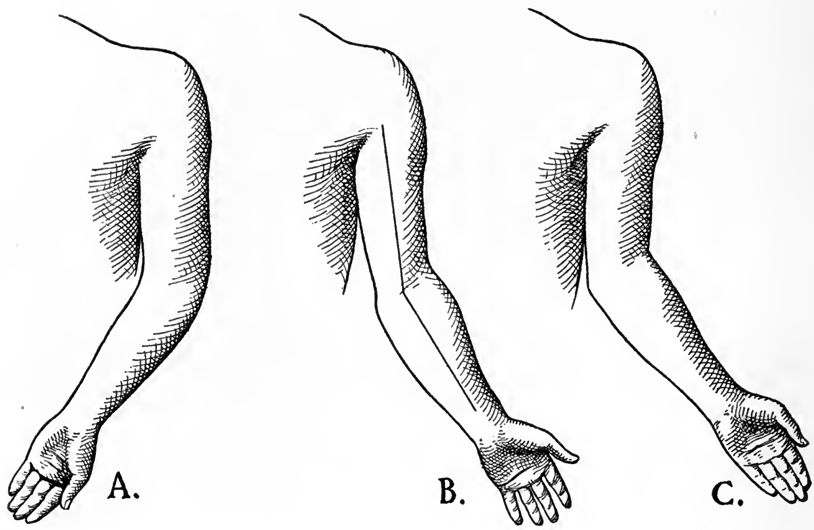


Fig. 117.
A, Cubitus varus deformity; B, normal carrying angle of arm; C, cubitus valgus deformity.

pressure upon the median nerve by the upper fragment. In 4 there was pressure upon the radial. The *flexion variety* occurs in adults after a fall upon the elbow. The line of fracture is also oblique from in front downward and backward. The upper fragment is displaced backward and the lower upward and forward, so that its sharp edge may penetrate the skin in front of the elbow or impinge upon the artery or nerves. In all supracondyloid fractures, especially those of the extension variety, there is always more or less displacement inward of the lower fragment. Less frequently it is displaced outward. At the same time there is angular displacement, owing to the outer portion of the lower fragment being lowered. If this is not corrected, the deformity known as cubitus varus (gunstock deformity) results.

(*b*) *Intercondyloid or T or Y Fractures.*—These are usually the result of great violence, the fracture often being a comminuted one. The simplest form is the T or Y form. In this a vertical or oblique fissure runs into the joint (Fig. 114) from an ordinary transverse or oblique supracondyloid fracture. There may be no dislocation, or the upper fragment is wedged between the two lower and forces them apart. If the fracture between the condyles is a mere fissure, the displacement is like that of an ordinary supracondyloid fracture. There may be so many fragments and lines of fracture that it is impossible to establish a classification for them. The most frequent cause is a fall upon the elbow. This produces the fracture in one of two ways: In one there is at first a supracondyloid fracture and the shaft pushes between the condyles. In the second the olecranon forces its way into the lower end of the humerus. It is most apt to occur between the ages of eighteen and forty and is often compound.

(*c*) *Epiphyseal Separation.*—In order to understand this class of cases it is necessary to remember that the lower end of the humerus develops from four separate centers of ossification. The first to appear is that of the capitellum in the third year. The next is the internal epicondyle in the fifth year. The centers in the trochlea and external epicondyle appear in the eighth year, according to Wolff.[32]

Epiphyseal separation is usually produced by direct violence, such as a fall upon the elbow while bent or the passage of a wheel or a kick from a horse. Indirect violence, such as a fall upon the outstretched hand, is less apt to cause it. After the eighth year, a displacement of the capitellum and external epicondyle may occur together. After the thirteenth year there are only possible, epiphyseal separations of the three coalesced nuclei (external epicondyle, capitellum, and trochlea) and the internal epicondyle. From the sixteenth or seventeenth year and up to the eighteenth or nineteenth only epiphyseal separation of the internal epicondyle is possible. Up to the eighteenth year, when there is a fracture in the neighborhood of the elbow-joint, the chances of its being epiphyseal are about 25 per cent. After the eighteenth year a separation of the capitellum and external epicondyle is called a fracture of the external condyle in adults, while separation of the trochlea and internal condyle is called a fracture of the internal condyle in adults. Isolated separation of the capitellum and trochlea together is rare. The lower fragment is usually displaced backward as in supracondyloid fractures.

(*d*) *Fractures of the Internal Epicondyles and Condyles.*—Fractures of the internal epicondyle usually occur between the ages of ten and twenty. They are nearly always separations of the epitrochlear epiphysis (Cotton[33]). They may or may not involve the elbow-joint. It is a not infrequent accompaniment of backward dislocation of the elbow. In the majority of cases the displacement is downward and forward (Fig. 118). Injury of the ulnar nerve frequently results from it. Fractures of the external epicondyle are very rare, and most of the recorded cases have been in adults. It is possible as an epiphyseal separation only up to the eighth year.

Fractures of the Internal Condyle.—This fracture is rare in children, but quite common in adults. The line of fracture extends obliquely downward and outward from the inner border of the humerus, passes through the olecranon fossa, and ends in the trochlea or even into the capitellum. The displacement may involve the fragment alone or include the latter and the ulna. The most frequent form of displacement is upward and inward and somewhat backward. The ulna remains attached to the fragment and pulls the radius with it, causing it to be dislocated partially or completely. This fracture may also be associated with backward dislocation of both bones of the forearm. Fractures of the external condyle are in reality oblique fractures of the lower end of the humerus. They occur more frequently in children than in adults. They follow a fall upon the outstretched hand or forcible abduction. The line of fracture runs obliquely down and inward. The fragment is very movable, and usually displaced upward and backward. Rotation of the fragment may occur so that the articular surface looks inward. Fractures of the capitellum,

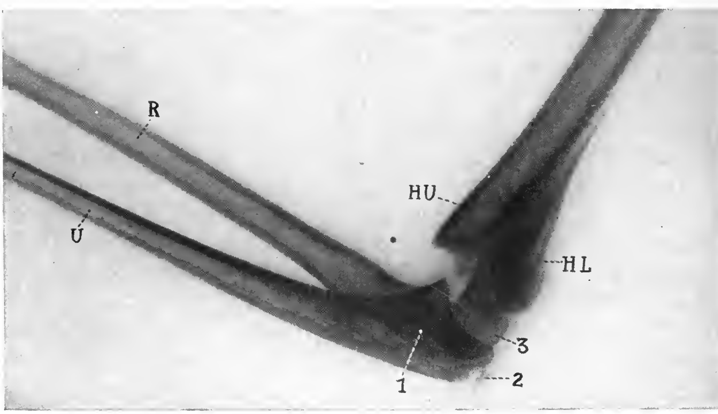


Fig. 118.—Deformity Following Supracondyloid Fracture of the Humerus.

The illustration shows how the lower fragment, HL, is displaced backward and upward, and the upper fragment downward and forward, HU, causing it to become prominent at the bend of the elbow. (See text.) R, Radius; U, ulna; 1, upper epiphysis of radius; 2, epiphysis corresponding to olecranon process; 3, lower epiphysis of humerus.

according to Kocher, are not so rare as has been thought. The capitellum is peeled off either completely or partially. Kocher, in 1896, reported four cases, and Lorenz[34] has recently published two more. The force producing it is indirect, the head of the radius being impacted against the capitellum. The fragment is always displaced backward.

Diagnosis.—1. (*a*) **Supracondyloid Fracture of the Humerus.**—Deformity may be present or not, according to the degree of displacement. If the latter is marked, there is a prominence at the back of the elbow in those fractures which follow a fall upon the elbow. These are called extension fractures (Fig. 124), and resemble a dislocation backward of the radius and ulna, but palpation shows the relations of the olecranon to the condyles to be normal (Fig. 115). The lower end of the upper fragment is often prominent and easily felt a little above the bend of the elbow. The deformity can usually be readily corrected by downward traction. Abnormal mobility and crepitus are easily elicited by grasping the forearm and lower end of the humerus firmly and moving it forward and backward while the shaft of the humerus is steadied with the other hand or by an assistant (Fig. 119).

1. (*b*) **Intercondyloid or T or Y Fractures of Lower End of Humerus.**—In this form of injury a skiagraph is often necessary in order to make an exact diagnosis. They are often compound, so that direct inspection is possible. The signs are the same as for supracondyloid fracture, but the relation of the condyles will be changed according to the degree of displacement. In some cases the condyles are so widely separated that the olecranon passes between them. Unless the swelling is too great, the condyles can be moved independently of each other and of the shaft.

(*c*) **Epiphyseal Separation.**—Beside the age and the history of the accident, there is abnormal mobility at the level of the epiphyseal line, *i. e.*, at a lower point than in the ordinary supracondyloid fracture. The abnormal mobility is most marked in an anteroposterior direction. In the majority of cases some deformity is present, due to the displacement backward of the lower fragment. The deformity is very apt to be reproduced after reduction. The characteristic muffled crepitus can usually be readily elicited. A fracture through the epiphysis can be distinguished from a dislocation of the elbow by the fact that measurement shows that the bony points on the lower fragment of the humerus still retain their normal relations to the olecranon. It differs from the supracondyloid fracture of older children and adults in showing a prominence, due to displacement forward of the upper fragment. This prominence is found at a lower level than in the supracondyloid variety. In general one should never make a diagnosis from an x-ray picture of an elbow-joint injury in children without referring frequently to x-ray pictures of the abnormal joint at various ages. The presence of a clear area caused by a normal cartilage may often lead one to think it a fracture line.

FIG. 119.—METHOD OF EXAMINING THE LOWER END OF THE HUMERUS IN CASE OF FRACTURE AT THIS POINT.

The forearm, when one is examining the right arm, is grasped by the left hand, the hand of the patient being allowed to rest upon the forearm of the examiner, while the right hand of the examiner grasps the region of the lower end of the humerus. For the examination of the left humerus the hands should be reversed.

(*d*) **Fracture of the internal epicondyle** can be best recognized by an *x*-ray examination. The fragment, if large, can be grasped and freely moved about. As stated before, it is in reality a separation of the internal epicondylar epiphysis.

Muffled crepitus can often be detected when the fragment is replaced. In fractures of the internal condyle the latter can be moved to and fro independently of the shaft by grasping it between the thumb and index-finger. This abnormal mobility is accompanied by crepitus. One of the most characteristic signs, if any displacement of the fragment has occurred, is the fact that when the relation of the three bony points is observed, the internal condyle is found above the level of the external condyle (Fig. 115). There is lateral mobility of the elbow-joint.

FIG. 120.—POSTERIOR VIEW OF ELBOW-JOINT IN NORMAL CHILD OF SEVEN.

FIG. 121.—FOREARM OF CHILD AT AGE OF THREE.

1. (*d*) *Fractures of the External Epicondyle and External Condyle.*—The former are rare and so difficult to recognize that for practical purposes it is only necessary to consider the fractures of the external condyle

itself. The latter occur more frequently than those of the internal condyle, especially in young persons. The fragment broken off includes the epicondyle, outer portion of the trochlea, and the capitellum (Fig. 122). It may be tilted or even rotated so that the broken surface looks upward and outward. The external condyle is found displaced upward when the three bony points at the back of the elbow are palpated. The fragments can usually be grasped between the fingers and moved independently of the shaft, accompanied by crepitus. In some cases a deformity is visible.

Treatment.—The position in which the elbow should be placed has

Fig. 122.—Posterior View of Skiagraph of Epiphyseal Separation of External Condyle (Jefferson Medical College Hospital).

Fig. 123.—Lateral View of Case Shown in Fig. 122 (Jefferson Medical College Hospital).

been the subject of much discussion. The same is true of early massage and passive motion. In regard to position, there are three methods, each of which has its warm supporters. These methods are, first, that the elbow should be maintained during the entire treatment flexed at a right angle; second, that the elbow should be in a position of acute flexion, *i. e.*, beyond a right angle, and, third, that the best method of treatment is by keeping the elbow extended.

It is a generally accepted fact that whichever method is employed, the most important point in the treatment is an accurate reduction of the fragments to overcome the two most frequent modes of displacement, viz., overriding and angular displacement. An anesthetic should always

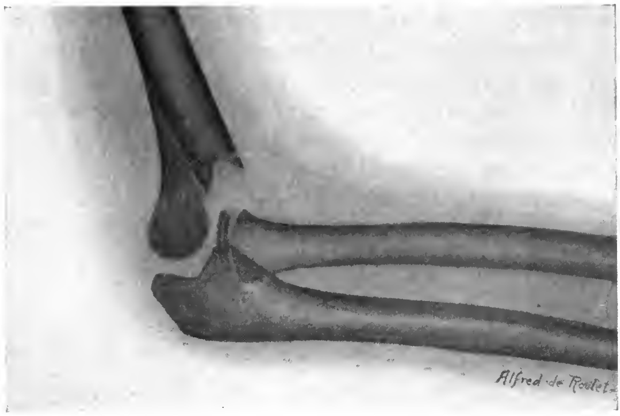


FIG. 124.—COPY OF SKIAGRAPH OF SUPRACONDYLOID FRACTURE, SHOWING BACKWARD DISPLACEMENT OF ~~UPPER~~ Lower FRAGMENT ("EXTENSION FRACTURE").
Compare with Figs. 125 and 126.

FIG. 125.—COPY OF SKIAGRAPH OF PATIENT SHOWN IN FIG. 124.
The deformity has been corrected by traction and flexion of elbow-joint.

FIG. 126.—SAME PATIENT SHOWN IN FIGS. 124 AND 125 WITH ELBOW EXTENDED. (See text.)

be given, especially in children, in order to make a diagnosis. In well-equipped hospitals a skiagraph should be made at this time, and again after reduction has been effected.

Reduction, in the majority of cases of supracondyloid fractures, can be best carried out by traction upon the elbow, the hands grasping the lower end of the humerus at the condyles. Countertraction is made at the same time by an assistant grasping the arm just above the seat of fracture. The reposition of the fragments is greatly aided by manipulation. In re-

Fig. 127.—Skiagraph of Cubitus Varus Deformity after Supracondyloid Fracture of Humerus.

Fig. 128.—Application of External and Internal Splints for Treatment of Fractures Close to the Elbow-Joint in Extension.

gard to the position in which to place the arm after reduction I personally employ and favor the flexion at a right angle. There are some cases in which placing the arm in an extended position (Fig. 128) for a week or ten days, and then flexing it to a right angle, will be necessary on account of the tendency toward displacement after reduction.

As Cotton[35] correctly states, "in children, at least, the outcome under any of the ordinary methods of treatment rarely gives ankylosis." The most reliable method of treatment for practically every case is the use of splints to maintain the elbow-joint in a right-angled position. These splints should be of only one of two materials, viz., metal or plaster-of-Paris. The perforated tin splints are the most convenient of the metal form. Ideal splints, which fit the parts accurately, can be made of plaster-of-Paris bandages by molding them to the forearm. They should extend from the level of the axilla in front and back (Fig. 129) to the middle of the palm of the hand. In children a convenient dressing is a posterior metal and an anterior heavy molded cardboard splint.

The fracture having been reduced, the splints are well padded with sheet wadding, and applied to the arm while the fragments are held in position by an assistant. A bandage should never be applied beneath the splints unless it is necessary to keep a dressing in place.

Fig. 129.—Anterior and Posterior Plaster Splints Applied. Most comfortable and efficient in injuries high up the forearm and at the elbow and lower part of upper arm (Scudder).

The anterior and posterior splints can be held in place by strips of adhesive plaster. One strip is placed close to the upper end of the arm, a second just above the elbow, a third at the upper part of the forearm, and a fourth close to the wrist.

There has been considerable discussion as to the advisability of the operative reduction and fixation of these fractures. This is rarely, if ever, necessary in a recent fracture. Attention has been frequently called to the exaggerated notion of displacement as gained by x-ray examinations in some cases. Excellent functional results are often obtained even though a considerable degree of displacement is shown in a skiagraph (Fig. 124). In old cases with deformity sufficient to interfere with the function of the joint operative treatment is indicated. Ankylosis in fractures of the lower end of the humerus is most apt to follow the T fractures.

The forearm in these cases should be placed in a position midway between supination and pronation, *i. e.*, thumb up, so that the function of the arm will be least interfered with should ankylosis occur. The opinion expressed on p. 135 in regard to the use of early massage and passive motion is especially applicable to fractures involving the elbow-joint.

The safest method is the following: The splints should be removed once a week and reapplied. At the end of four weeks they can usually be removed and the arm kept in a sling. During the fifth week the entire arm is slightly rubbed for five to ten minutes daily.

The patient is encouraged to make slight active movements, the range of motion being increased daily. It is inadvisable to attempt to force passive motion. This should be begun gradually at the end of the fifth to sixth week. Before this time passive motion will often increase instead of decreasing the rigidity.

Later the range of passive motion is increased daily, and dumb-bells or gymnastic apparatus used. Bardenheuer has obtained excellent results in fractures with marked displacement by the use of extension (Fig. 113).

Prognosis in Fractures of the Lower End of the Humerus.—In general it may be said that the younger the patient, the more rapid the recovery. If the fracture has been accurately reduced, the prognosis is good in the majority of cases. Union in three to four weeks in children, and four to six weeks in adults, is the rule. Non-union is very rare. Cubitus varus or gunstock deformity is a bowing outward of the arm at the elbow. It is a much more frequent sequel of fractures of the lower end of the humerus than a bowing inward or cubitus valgus. Both of these deformities are the result of imperfect reduction and not of retardation of growth (Cotton).

Both of these deformities occur only after a complete or partial supracondyloid fracture. It is rare for epiphyseal separations to cause any arrest of growth. In a properly managed case the prognosis, both in adults and children, is good as regards both deformity and restoration of function of the joint. Ankylosis due to an excessive callus-formation is most apt to occur in those fractures which enter the joint, or where considerable para-articular thickening exists.

FRACTURES OF THE BONES OF THE FOREARM.

1. In the vicinity of the elbow-joint. The possible fractures of the radius and ulna which occur in the vicinity of the elbow are:

(*a*) Fractures of the olecranon.

(*b*) Fractures of the coronoid process.

(*c*) Fractures of the upper third of the shaft of the ulna.

(*d*) Fractures of the head or neck of the radius.

(*e*) Fractures of the upper third of the shaft of the radius, with or without an accompanying fracture of the ulna.

(*a*) **Fractures of the Olecranon.**—These are the result of direct violence in the majority of cases. The contraction by the triceps probably plays an important part. Fractures by muscular action alone have been recorded, but this mode of production is infrequent.

The line of fracture is usually transverse or oblique, and passes through the middle or base of the process.

The fracture is often a compound one. Even in the simple variety it is always accompanied by considerable swelling and contusion of the overlying soft parts. The joint is filled with blood.

Diagnosis.—When a considerable separation of fragments occurs, the fracture can be readily recognized by the gap or depression at the back of the elbow. A separation of sufficient degree to be recognized by inspection or palpation is exceptional. If such a loose fragment is present, it can be recognized by grasping it between the thumb and finger and moving it laterally. Voluntary extension of the elbow is usually lost. If the swelling is marked, the diagnosis can often be made only through the use of the x-ray (Fig. 132). A traumatic olecranon bursitis will at times resemble or may obscure a fracture of the olecranon. The swelling, however, is more circumscribed; there is no interference with extension and no abnormal mobility.

Fig. 130.—Location of Most Frequent Fractures of Ulna.

1, Of tip of olecranon; 2, through base of olecranon; 3, of coronoid; 4, of upper third; 5, oblique of middle of shaft; 6, just above wrist-joint.

Fig. 131.—Location of Most Frequent Fractures of Radius.

1, Through head of radius, extending into joint; 2, through neck; 3, oblique of upper third of shaft; 4, fracture at middle of shaft; 5, typical Colles'; 6, styloid process.

In fractures of the olecranon process crepitus can at times be obtained by extending the forearm and pushing the fragments together. In the interpretation of an x-ray picture in young subjects the possibility of a detached bone-shadow being a center of ossification must not be forgotten. The shaft unites with the epiphysis at the age of eighteen.

Treatment.—Union, as a rule, is fibrous, rarely bony, even though the fragments be in accurate apposition. If a considerable interval exists between the two fragments which is not overcome by the treatment, non-union may occur or the function of extension be greatly interfered with.

The best method of reduction is to extend the forearm. This will aid in obtaining either bony or close fibrous union. If there is a considerable separation which increases when the elbow is flexed, an anterior splint of plaster-of-Paris, metal, or wood should be used, extending from the level of the axilla to the finger-tips. If the separation is slight and flexion of the forearm does not increase it, the elbow can be kept in a slightly flexed position. The limb should be well padded and held in position by strips of adhesive plaster.

The operative fixation of the fragments has been frequently recommended during recent years. This method will, of course, give an ideal result. Such excellent function follows the short fibrous band of union which occurs after ordinary non-operative methods of treatment, however, that a suture is rarely indicated except in cases of non-union. If a suture is required, an absorbable material like kangaroo tendon, inserted through the aponeurosis alone, suffices.

The anterior splint should be used for four weeks. During this period it is to be removed once a week, and the back of the elbow massaged and the splints reapplied. Passive motion should be very cautiously employed at the end of the fourth week.

Some European surgeons (Grimm, Sachs, Kraske) recommend the treatment of fractures of the olecranon throughout their course, by massage. A splint is applied for the first two to four days, and then massage, combined with active and passive motion, begun. The method has given very satisfactory results, but would seem too radical for routine use. The use of massage during the course of the ordinary treatment, when given by an experienced masseur without passive motion, is to be warmly recommended.

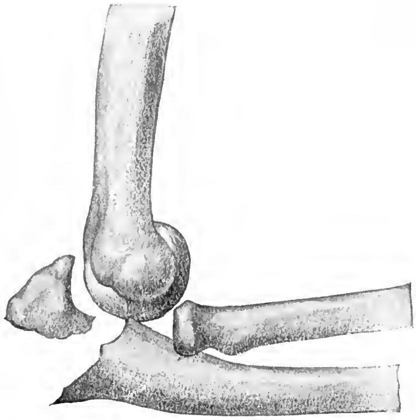


Fig. 132.—From a Drawing of an x-Ray of a Fracture of the Olecranon Process.

Fractures of the Coronoid Process.—Isolated fractures of this portion of the upper end of the ulna, although rare, occur more frequently than was formerly thought.[36] About 20 cases have been reported. It occurs far more often as an accompaniment of backward dislocation of the bones of the forearm at the elbow. When it occurs in connection with such a dislocation, there is a tendency for the bones to slip back again after reduction. In some cases the loose fragment of the coronoid may interfere with full flexion of the elbow-joint. When fracture of the coronoid process occurs as an isolated injury, it is almost always the result of indirect violence, usually after a fall upon the outstretched hand.

The diagnosis cannot be made in many cases without the aid of the x-ray. In others the existence of other injuries of the bones composing the elbow-joint can be excluded one by one.

There is sharp pain upon pressure over the coronoid, which is increased by flexion of the elbow. It is seldom possible to feel a fragment and to move it. The forearm can be more readily pushed backward than under normal conditions, and this act may be accompanied by crepitus.[37] The best means of diagnosis is by the x-ray.

Treatment.—If the fragment is dislocated or excessive callus-formation occurs, it may interfere with the function of the joint. If it occurs as a complication of a dislocation of the elbow-joint, special attention should be paid to early mobilization. In cases of isolated fracture of recent origin, the best treatment is to immobilize the elbow in a right or acute angled position, depending upon the degree of displacement of the fragment. Light passive and active movements should be begun during the third week. In old cases, where the fragment interferes with flexion, it is best to operate and remove the obstruction.

Fractures of the Head or Neck of the Radius.—Instead of being an exceedingly rare occurrence, both of these fractures have been found to be frequent. T. Turner Thomas,[38] in 1905, collected 103 cases, and Prat,[39] in 1906, referred to 20 in the literature and added 4 of his own. The fractures are most apt to follow a fall upon the hand with the elbow extended. Fractures of the neck are usually associated with those of the head of the radius and are frequently impacted. The line of fracture in fractures of the neck is always transverse or oblique, unless it is a continuation of a fracture of the head. As a general rule, the lower fragment is pulled forward and upward by the biceps and the upper fragment displaced backward and outward.

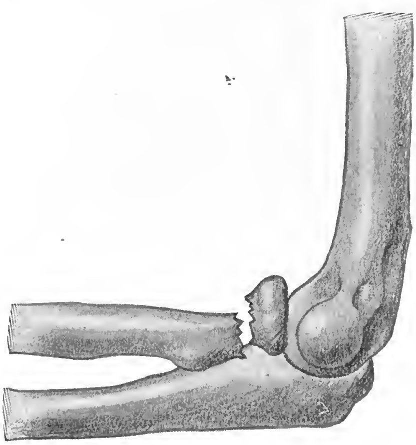


Fig. 133.—Drawing made from a Skiagraph of a Fracture of the Neck of the Radius.

Fractures of the head of the radius may be complete or incomplete. The line of fracture is usually vertical, and when complete, may extend into the neck. In the complete the fragment may hang by a shred or be movable and act as an intra-articular foreign body.

Fractures of the head or neck may occur as isolated injuries or be an accompaniment of other fractures or dislocations of the bones of the elbow.

Diagnosis.—In a simple fissure or incomplete fracture the symptoms may be thought to be those of a contusion or sprain, unless a skiagraph has been made. The swelling of the joint may be so marked as to obscure the injury. The most characteristic signs are the presence of pain located over the upper end of the radius. In a sprain, the head of the radius (Fig. 116) will be found to rotate, while in a fracture of the neck this movement will be absent when the forearm is rotated. In some cases it may be possible to elicit crepitus by alternately pronating and supinating the forearm (Fig. 116). If the fragments are not in contact, crepitus may be absent.

In fractures of the neck one can at times feel a bony prominence over the front of the elbow. In muscular individuals, in the absence of crepitus, the diagnosis can be made only by the use of the x-ray. In the patient whose x-ray picture is shown in Fig. 133, the injury was suspected from the presence of severe, well-localized pain upon pronation and supination. If no displacement exists, the x-ray may show no fracture.

In cases with displacement the prognosis is not as good as in the fissured variety. The fragment may unite with the coronoid process and interfere with the rotation of the forearm. Excessive callus-formation or the complete detachment of the fragment may prevent flexion and extension of the elbow-joint.

Treatment.—Unless such marked displacement exists as to interfere with the functions of the elbow or of the upper radio-ulnar joint, it is best to immobilize the elbow for three to four weeks in a right-angled position. After this period massage and active and passive motion will restore good function in the majority of cases. Especial attention should be given to movements of pronation and supination.

If a fragment of the head is detached so as to lie free in the elbow-joint, it can be removed. If the callus-formation is such as to interfere with motion, no harm can result from the excision of the head of the radius. Both of these operative procedures are, however, rarely necessary.

Fracture of the Bones of the Forearm.—These may either occur together or either bone may be broken separately.

(*a*) **Fracture of Both Bones of the Forearm.**—The cause may be direct, *e. g.*, being run over, kicked, or struck, or it may be indirect, like a fall upon the hand. In those due to direct violence the seat of fracture may be at any level. In the indirect form it is usually in the lower third of the forearm. In the direct, the fractures are usually at the same level, while in the indirect, the seat of fracture is higher in the ulna than in the radius.

The fracture may be compound, multiple, or comminuted. The majority of fractures lie in the middle third of the forearm; the next most frequent seat is the lower third. Fractures of the upper third are infrequent, on account of their well-protected position. The fracture may be complete or incomplete. In children the incomplete or greenstick fracture, in the form of an infraction, is by far the most frequent variety and is often overlooked. Complete fractures are either transverse or oblique. The displacements are lateral, with or without overriding in the transverse, overriding in the oblique, and angular displacement in both forms. Adhesion of the two bones to each other is rare.

Diagnosis.—The symptoms vary according to whether the fracture is complete or incomplete. If a child complains of pain after a fall upon the hand or forearm or ceases to use the arm, a search for an incomplete or greenstick fracture should be made. The radius and ulna can be palpated in children throughout almost their entire length, so that a bowing or angle is readily detected. The other signs are localized pain and tenderness. An x-ray examination should be made in every suspected case. One bone may be completely broken, and the other only incompletely. Complete fractures of either or both bones of the forearm are not difficult to recognize unless the individual is very muscular or very fat. When the arm is grasped in the manner shown in Fig. 116, abnormal mobility and crepitus can be readily detected. At times the diagnosis may be made from the deformity alone, which is either visible or can be felt by palpating the bones.

Prognosis and Treatment.—The prognosis of fractures of the bones of the forearm depends upon the method of treatment. Union usually occurs in four to five weeks, but one of the bones, especially the radius, may require a longer period. Non-union may occur and is not very uncommon.

The possible complications other than delayed or failure of union are those due to faulty treatment. In no part of the body are the various complications of compound fracture, such as tetanus, infection with pyogenic or gas-producing organisms, etc., more likely to occur than in those of the bones of the forearm. For this reason the primary cleansing and disinfection should be most thorough.

The ends of the bones are very apt to penetrate the skin and then be withdrawn into the tissues again. If any doubt exists as to their condition, it is best to enlarge the wound and thoroughly disinfect the soft parts and ends of the bones, resection of the latter seldom being necessary. Gangrene or ischemic muscular atrophy is very apt to follow too tight an application of the retentive dressing. Although adhesion of the callus of one bone to that of the other is infrequent, it is most apt to occur if the splints are narrower than the forearm, thus pressing the bones together. This same lack of proper treatment will tend to increase any lateral or angular displacement which may be present.

In addition to the possibility of the bony union of the radius and ulna, a false joint may form if the fractures are at the same level.

Reduction is effected by making extension and counter-extension. The patient's hands are grasped and traction made while the hand is in a position of supination. An assistant makes counter-extension by grasping the arm just below the elbow. The fragments can usually be brought directly into line during this procedure, by direct manipulation with the thumbs in front and the fingers behind.

The interosseous space is greatest when the forearm is midway between supination and pronation, and this is the best position in which to place it during healing of the fracture. Whenever there is danger of union between the two bones, the forearm should be kept in full supination. No bandage should be applied beneath the splints except in compound fractures, and then only lightly. This will avoid any constriction and possible gangrene.

The two most frequently employed methods of treatment are: (*a*) The application of anterior and posterior wooden splints, or (*b*) of molded plaster-of-Paris splints. A circular plaster cast should never be used, especially if any swelling exists.

If wooden splints are used (Figs. 134, 135, 136), they should be one-fourth inch in thickness and a little wider than the forearm at its most muscular part, *i. e.*, in its upper third.

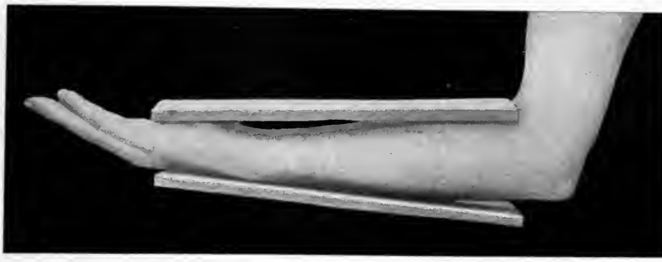


Fig. 134.—Length of Wooden Splints used in Treatment of Fractures of Both Bones of Forearm or in Colles' Fracture. (See text.)
The portions which need a special amount of padding are the flexor surfaces of the wrist and lower third of the forearm.

The anterior splint should extend from the bend of the elbow to the middle of the palm of the hand. The posterior splint should extend

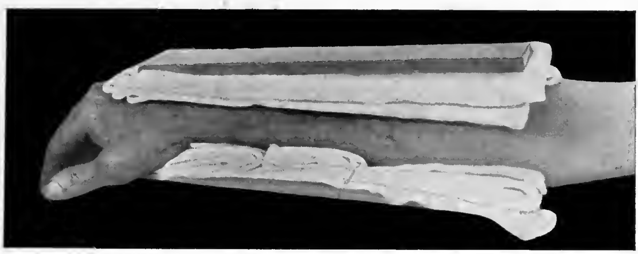


Fig. 135.—Wooden Splint for Use in Fracture of Both Bones of the Forearm or in Colles' Fracture.
Note how the concavity shown in Fig. 134 has been filled by an extra amount of padding.

from the level of the head of the radius to a point just proximal to the metacarpophalangeal joints. These lengths will permit free movements

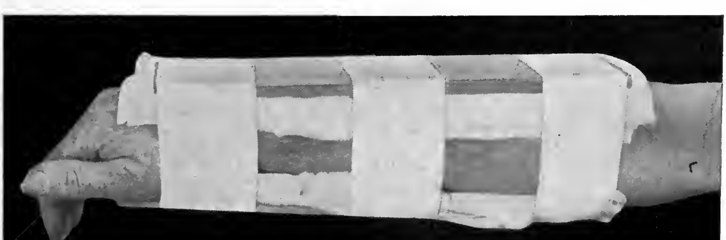


Fig. 136.—Wooden Splint Shown in Fig. 135, Held in Place by Pieces of Adhesive Plaster.
The dorsal splint extends to the middle dorsum of the hand; the anterior splint extends to the middle of the palm of the hand, thus permitting the free motion of the thumb and fingers.

of the fingers and metacarpophalangeal joints, and prevent any tendency to stiffness from adhesions of the tendons to the tendon sheaths or from arthritis of these smaller joints. Both splints are to be padded with three or four thicknesses of sheet-wadding. Especial care should be taken to place an extra amount of padding over the front of the wrist (Fig. 135). The splints are applied while the forearm is held in a position of half supination and pronation. Three straps of adhesive plaster, each two inches wide, are used to hold the splints snugly, but not too tightly together (Fig. 136).

If the fracture is in the upper third of the forearm, a right-angled splint is used to immobilize the elbow.

The use of molded plaster-of-Paris splints (Fig. 138) is to be especially recommended. They can be so accurately fitted to the depressions and elevations of the forearm and wrist as completely to immobilize the fracture. The posterior splint should extend from the middle of the dorsum of the hand to a point just above the olecranon. The palmar splint should extend from the lower third of the humerus to the middle of the palm of the hand, the elbow being held at a right angle while the plaster is hardening. The forearm is placed in a position midway between supination and pronation.

Fig. 137.—Method of Converting a Greenstick Fracture of the Ulna or Radius into a Complete One.

The arm is grasped by the two hands of the operator, one being placed at the elbow and the other at the wrist, and the arm is bent in a direction opposite to that on which the fracture is situated.

All splints should be removed once a week and readjusted. At the end of the first week the swelling has usually decreased to such an extent that the wooden splints require considerable extra padding. If the molded plaster splints are too loose, a strip can be cut along the edge, the entire length of the splint. The cut edges of the plaster should be covered with adhesive plaster to prevent crumbling of the plaster. At the end of the fourth week union is usually firm and the splints can be removed and light massage and movements begun. Active motions, especially pronation and supination, are best carried out by the patient grasping a light (one-half pound) wooden dumb-bell and exercising the forearm while seated at a table upon which the tip of the elbow is supported. The treatment of delayed union does not differ from that previously given.

The treatment of incomplete or greenstick fractures requires special mention. In order to correct the deformity it is necessary to convert the fracture into a complete one. This is done by administering an anesthetic and bending the forearm as shown in Fig. 137, by grasping it at the elbow and just above the wrist, and flexing it in a direction opposite to that of the original. If the x-ray shows that the bending, as found on palpation, is toward the radial side, the forearm must be flexed in the opposite direction, and vice versâ. The splints should be kept on for four weeks.

Fractures of the Shaft of the Ulna Alone.—These are almost invariably the result of direct violence, such as a fall or a blow upon the ulnar side of the forearm. If the radius has not been broken, there is no shortening present. The diagnosis is made by palpating the displacement and by the use of the x-ray. This is easy on account of the superficial position of the posterior border. In some cases it may be possible to elicit crepitus. The finger should be passed along this border and any irregularity noted. In greenstick fractures the only signs are a bowing at the point of fracture and a constant pain referred to one spot.

Fracture of the upper third of the ulna alone is a not infrequent complication of a forward dislocation of the radius (Fig. 114). The treatment is essentially that outlined for fracture of both bones of the forearm. The displacement, if any exists, can be best corrected by pressure upon the displaced fragments.

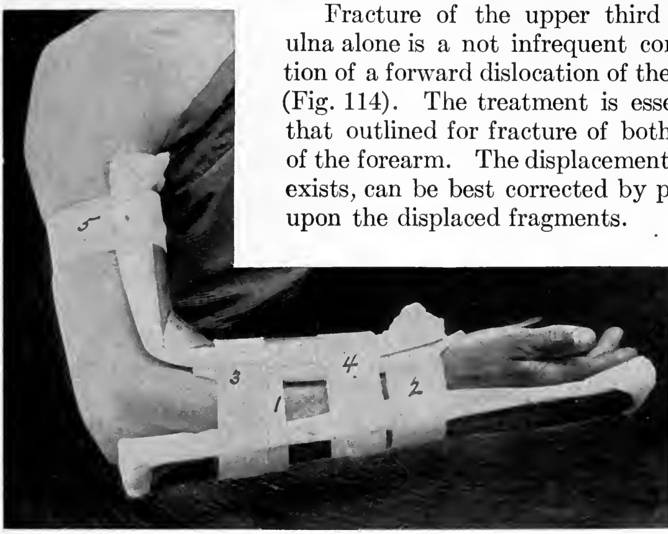


Fig. 138.—Fracture of the Bones of Forearm.

Forearm supinated. Anterior and posterior splints and tin internal angular splints. 1 and 2, Straps holding anterior and posterior splints; 3, 4, and 5, straps holding internal right-angle splint (Scudder).

Fractures of the Shaft of the Radius Alone.—Isolated fracture of the shaft of the radius is less frequent than is that of the ulna. It usually follows direct violence. The displacement is angular and varies according to the seat of fracture. If the latter is above the insertion of the pronator radii teres, *i. e.*, in the upper third of the bone, the upper fragment is completely supinated by the biceps, while the lower fragment is drawn toward the ulna and fully pronated by the two pronator muscles. If the fracture is below the insertion of the pronator radii teres, *i. e.*, at or below the middle of the bone, the upper fragment is drawn forward by the biceps and inward by the pronator teres. The lower fragment is drawn toward the ulna by the pronator quadratus.

The diagnosis of fracture of the shaft of the radius alone is based upon the presence of crepitus and abnormal mobility when the hand is grasped (Fig. 116) and the forearm passive, supinated, and pronated. The voluntary rotary movements are also lost, and there is a well-localized point of tenderness and pain.

In greenstick fracture the chief symptoms are a deformity found upon passing the fingers along the bone and the presence of a localized pain. The treatment is the same as that for fracture of both bones (p. 198) of the forearm.

Displacement is corrected by traction upon the wrist and exerting pressure over the ends of the fragments. If above the middle of the bone, the forearm should be held supinated and an anterior right angled and a straight posterior splint used, the elbow being flexed to a right angle (Fig. 138); in fractures below the middle third, the ordinary anteroposterior splints, with the forearm in semipronation.

INJURIES IN THE VICINITY OF THE WRIST-JOINT.

The following conditions must be thought of in this region:

(*a*) Fractures of the lower end of the radius—Colles' fracture.
(*b*) Fracture of the styloid process of the ulna.
(*c*) Fracture of both radius and ulna near the wrist.
(*d*) Fractures and dislocations of the carpal bones.
(*e*) Dislocations of the wrist-joint.
(*f*) Dislocations at the carpometacarpal joints.

As in the case of injuries of the shoulder- and elbow-joint, familiarity with normal conditions is of the greatest aid in making a diagnosis. The injured wrist should always be compared with the opposite sound one. One should first observe the presence of deformity, which is often quite marked (Fig. 141). The injured hand is then grasped by the hand of the examiner, while upward and downward movements are imparted to the lower end of the radius and ulna to determine abnormal mobility and crepitus. A second and very useful method is to grasp the lower end of the forearm with the two hands of the examiner, as shown in Fig. 140. In many of the injuries, especially of the carpal bones, an *x*-ray picture will be found to be indispensable.

Fractures of the Lower End of the Radius (Colles' Fracture).—The radius, whose structure in the entire shaft is quite compact, suddenly expands into more cancellous and less resistant bone about one inch above the lower end. The articular surface of the radius possesses not only a groove for the ulna, but it articulates with all of the first row of carpal bones, the ulna taking no direct part in the radio-ulnocarpal articulation. The lower epiphysis of the radius lies entirely extra-articular, and joins with the shaft at the age of eighteen to nineteen years.

Fractures of the lower end of the radius are very frequent, constituting about 10 per cent. of all fractures. The typical fracture of the radius is that commonly known as Colles' fracture. In the majority of cases the line of fracture is from one-third to three-fourths of an inch above the articular surface. It is usually transverse, but may be oblique in a lateral or anteroposterior direction. Marked dentation of the

FIG. 139.—METHOD OF EXAMINATION FOR FRACTURES OF THE LOWER END OF THE RADIUS.

In the examination of the left forearm the wrist is grasped by the left hand of the examiner close to the point of fracture, while the right arm grasps the bone just above the suspected point of fracture. In the examination of the right arm this order should be reversed.

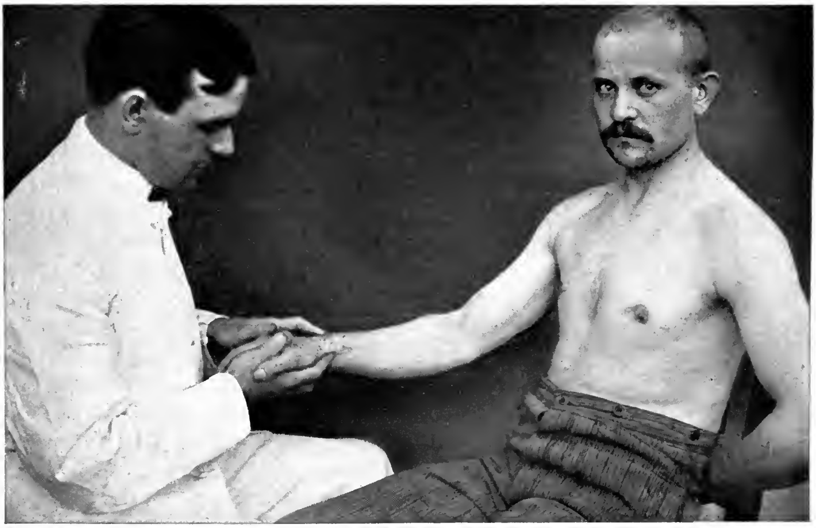


FIG. 140.—ONE OF THE METHODS OF EXAMINATION FOR FRACTURE OF THE LOWER END OF THE RADIUS.

In the case of the right radius, the patient's hand is grasped by the right hand of the examiner as though shaking hands. The index-finger of the examiner's right hand is placed below the lower end of the radius, while the fingers of the examiner's other hand are placed on the dorsal side of the same bone. By a rocking or to-and-fro motion a false point of motion can be readily detected.

fragments is not infrequent, and in very young patients the fracture often passes through the epiphyseal cartilage.

At a later period, *i. e.*, close to the age of eighteen, the line of fracture

FIG. 141.—VIEW FROM RADIAL SIDE OF A TYPICAL SILVER-FORK DEFORMITY FOLLOWING COLLES' FRACTURE.

is more apt to involve the diaphysis. The displacement is somewhat complicated. First, the lower fragment is either displaced backward without crushing, or more often the displacement is entirely angular. The lower fragment turns upon its anterior edge (Stimson) as upon a hinge, crushing or penetration with impaction taking place posteriorly and externally. The articular surface, instead of looking downward and forward, as it does normally, looks down and backward. Second, in addition to this angular displacement, there is also more or less lateral displacement. The lower fragment is displaced toward the radial side of the forearm, *i. e.*, outward, and the upper remains fixed to the ulna and is displaced toward the ulnar side or inward. There is also more or less rotary displacement. The lower fragment is rotated on a transverse axis, so that the styloid process looks upward.

FIG. 142.—DEFORMITY FOLLOWING FRACTURE AT THE LOWER END OF THE RADIUS.

Note the displacement of the hand and lower end of the radius toward the radial side of the arm, causing the styloid process of the ulna to become abnormally prominent.

Instead of the lower fragment being displaced backward in such a manner as to form an angle with the shaft, it may be displaced toward the flexor surface, giving rise to the deformity known as the gardener's

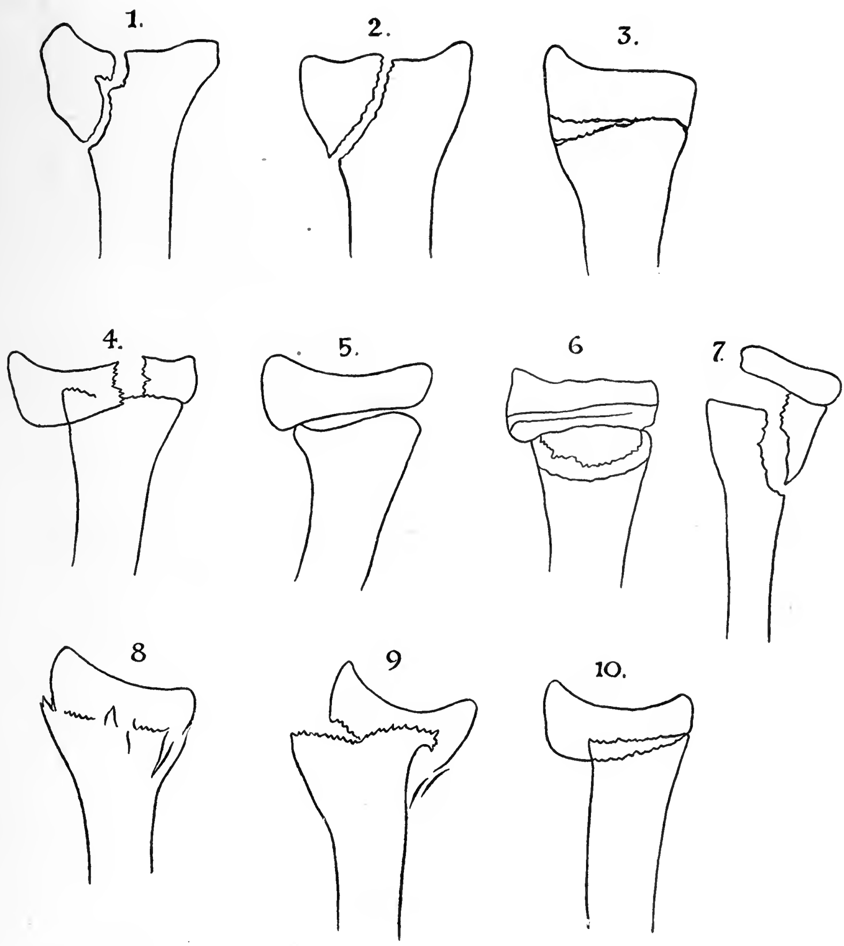


FIG. 143.—OUTLINES OF *x*-RAY PICTURES OF VARIOUS FORMS OF FRACTURE OF THE LOWER END OF THE RADIUS.

1, Through base of styloid process; 2, through inner angle of lower end of radius; 3, transverse fracture without displacement; 4, comminution of distal fragments; 5, separation of epiphysis; 6, 7, separation of epiphysis with chips of diaphysis; 8, impaction of lower into upper fragments; 9, typical Colles' (lateral view); 10, reverse Colles'.

spade (Fig. 144). Dr. J. B. Roberts[40] has collected 20 clinical cases and 31 museum specimens. F. T. Stewart[41] has added 2 of his own cases.

The name given to the displacement in a typical Colles' fracture is silver-fork deformity (Fig. 141). The various forms of fracture at the lower end of the radius are shown in Fig. 143. They are thus classified as the result of a large number of x-ray examinations.

1. Fracture through the base of the styloid process. This is an oblique intra-articular fracture. It is rare and not accompanied by any deformity.

2. Fracture through the inner angle. This is similar to class 1. It is accompanied only by slight enlargement of the wrist. It is easily reduced.

3. Transverse fracture at or above the epiphyseal line (in adults without displacement). It is associated with practically no deformity. As a rule, crepitus can be elicited. In 66 per cent. of the cases there is fracture of the ulnar styloid. In this variety it is important to take a lateral and an anteroposterior view, in order to determine the amount of posterior displacement.

FIG. 144.—CHARACTERISTIC SWELLING OF WRIST-JOINT AND DEFORMITY IN RECENT COLLES' FRACTURE.

Note the fullness on the flexor surface of wrist, due to displacement downward of the upper fragment of the radius, and the more distal prominence on the dorsal surface of the wrist, due to displacement upward of the lower fragment of the radius. Note also the swelling and obliteration of the normal depressions corresponding to the wrist-joint.

4. Comminuted Colles' fracture. This differs from the typical Colles' fracture (No. 9 of Fig. 143) only in the fact that the distal fragment is broken into two or more pieces. The classic deformity of a Colles' fracture is always present. There may be impaction of the fragments. If this is present, it should be broken up. Perfect reduction is always difficult, frequently impossible. There is usually some deformity in spite of efforts at perfect reduction.

The styloid process of the ulna is also often broken and inverted. Comminuted fractures constitute about one-third of the cases. Reduction is difficult, and should be done with the aid of an anesthetic, and controlled after a few days by a second x-ray picture.

5. Separation of the lower epiphysis of the radius. The lower epiphysis unites with the shaft about the twentieth year. The injury is a quite common one, but often overlooked. The displacement is backward, but the fragments remain in contact. The swelling is most marked

upon the palmar side of the wrist, instead of upon the extensor surface, as in an ordinary Colles' fracture (Fig. 141). There is usually no lateral deformity. The fracture can seldom be recognized without a lateral x-ray picture.

6. Separation of the epiphysis with a chip broken from the diaphysis. This is a variety of epiphyseal separation and differs but little from it.

7. Impaction of the lower fragment into the shaft of the radius. This is quite rare. There is always deformity, especially posteriorly, *i. e.*, dorsal and slight radial displacement. In treatment, the impaction must be broken up and the deformity reduced.

8. Typical Colles' fracture. The characteristics of this class are referred to later under the head of diagnosis. Codman[42] divides Colles' fracture into two forms: (*a*) Those in which the radial displacement is most marked; and (*b*) those in which the posterior displacement of the lower fragment is most marked. In all cases both deformities are present to some extent. The amount of impaction varies. In the first variety the styloid process of the ulna was always, while in the second one it was not always, broken. The chief difficulty in the treatment of the typical Colles' fracture is perfect reduction (see Treatment).

9. Stellate fracture of the lower end of the radius with longitudinal fissures extending into the shaft. There is little deformity and no impaction.

10. Reversed Colles' fracture. This is the variety to whose deformity Roberts has given the term gardener's spade. The ulnar styloid is usually broken.

Treatment of Colles' Fracture.—A. In the treatment of a Colles' fracture one should have a clear conception of the usual displacement of fragments and the resultant deformity. In an ordinary Colles' fracture the lower fragment is displaced—(*a*) toward the dorsal or extensor side of the forearm; (*b*) toward the radial side of the forearm; and (*c*) there is often some axial rotation. In the reversed Colles' fracture the lower fragment is displaced forward, *i. e.*, toward the flexor aspect of the forearm. It is also necessary to remember the fact that impaction of fragments is usually the greatest obstacle to perfect reduction.

The most important task in the treatment of a Colles' fracture is to correct the deformity by reduction of the fragments and, having accomplished this, to maintain them in accurate position until firm union has been secured. Reduction should be accomplished as soon as possible after the injury. The simplest method of reduction is to have the patient seated, with the injured arm flexed at the elbow, resting upon a table.

B. The patient is seated opposite the surgeon, who grasps the hand of the injured arm with his corresponding hand, as if to shake hands. Traction is now made upon the wrist, while direct pressure is made over the displaced lower fragment of the radius, with the thumb and fingers of the surgeon's other hand. By a little gentle manipulation and traction the fragments can often be pushed into place. This method also permits the correction of any axial deformity by rotation of the lower fragment through the grasp upon the hand.

If it is impossible to correct the deformity by this method, a general anesthetic, preferably ether or nitrous oxid, should be given. The perfect relaxation obtained through the use of a general anesthetic is especially desirable in the reduction of impacted fractures. Here *the impaction must be broken up before reduction can be made,* and this requires the use of great force. By grasping the arm forcibly above the fracture with one hand, and the patient's hand with the surgeon's other hand, the impaction is broken up by traction and side-to-side manipulation.

C. Pressure should be made upon the radial side of the lower fragment, in order to correct the elevation of the styloid process of the radius,

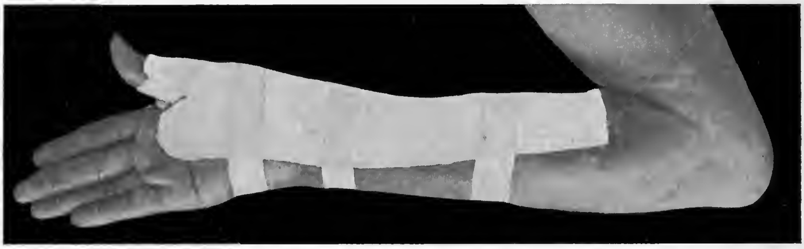


Fig. 145.—Molded Plaster-of-Paris Splint for Use in Treatment of Colles' Fracture.

which is often the result of a rotation of the lower fragment on an anteroposterior axis. After reduction has once been effected, there is little tendency for it to recur.

Splints may be made of wood, plaster-of-Paris, heavy cardboard, or fiber. A very useful method is to use two wooden splints. The posterior one extends from the elbow to the middle of the dorsum of the hand (Fig. 134). The anterior one should extend from the bend of the flexed elbow to the middle of the palm of the hand. These lengths will permit free movements in the metacarpophalangeal and interphalangeal joints during the entire course of treatment. The splints should be a little wider than the forearm at its most muscular part, and they should be liberally padded with sheet-wadding. A wedge-shaped pad of cotton is placed upon the front of the arm, over the lower end of the upper fragment. A second pad is placed on the posterior surface over the upper end of the lower fragment. The hand and forearm being held midway between pronation and supination, the splints are applied and held in position by three strips of adhesive plaster, each two inches wide (Fig. 136), snugly but loosely applied. Active and passive movements of the fingers are begun as soon as the splints have been applied. The splints should be removed and reapplied once a week until firm union has been secured, *i. e.*, at the end of four weeks. Massage of the forearm and hand for ten minutes twice daily is begun, followed by active and passive movements.

If there is much tendency to recurrence of the displacement of the upper fragment toward the ulnar side of the forearm, a wooden, pistol-shaped splint can be used so as to secure adduction of the hand.

Instead of wooden splints, some prefer to use the metal Levis splint on the anterior side, and a molded cardboard splint posteriorly. Of late, molded plaster-of-Paris splints have been extensively employed. These are made according to the method described on p. 117. They fit the arm accurately, and the fragments can be better secured than by any other method. If adduction of the hand is required, this can be secured before the plaster hardens (Fig. 145).

The treatment of a reversed Colles' fracture is essentially the same as that described for the ordinary form, but the pads are changed, an anterior one being placed over the lower fragment and a posterior (dorsal) one over the upper fragment.

If the line of fracture extends into the wrist-joint, and in cases where there is a comminution of the lower fragment, ankylosis, or at least some degree of limitation of motion, is likely to follow.

If the fingers are left free, as described, and the patient encouraged to move them frequently during the day, stiffness of the fingers from a tenosynovitis will be rare. In cases of old unreduced fractures with deformity excellent results have been obtained by osteotomy.

Fractures of Carpal Bones.*—This injury occurs far more often in men than in women. Injury to the right wrist predominates over the left by a much smaller margin; the decade during which the injury has most frequently occurred has been between twenty-five and thirty-five years.

The causes of carpal injuries have been trauma, either direct or indirect—more frequently the latter. These have been the result of falls from varying heights, the force exerted having usually been forcible extension or flexion, occasionally with rotation and abduction. Carpal injuries have occurred combined with injuries to other bones, *e. g.*, fractures with dislocations, fractures of radial or ulnar styloid, Colles' fracture, fracture of a metacarpal, especially that of the thumb or either bone of the forearm, especially the radius. No carpal bones have been exempt from injury, though there is a great variation in frequency, which is represented by the following order: Scaphoid, semilunar, pisiform, os magnum, trapezium, trapezoid, unciform, and cuneiform.

*The writer is indebted to the classic monograph of Codman and Chase[42] for valuable aid in the preparation of this section.

Simple fracture of the scaphoid gives a definite clinical picture, and may be recognized even without the *x*-ray by the association of the following symptoms, viz.: (*a*) The history of a fall on the extended hand; (*b*) localized swelling in the radial half of the wrist-joint; (*c*) acute tenderness in the anatomic snuff-box when the hand is adducted; (*d*) limitation of extension by muscular spasm, the overcoming of which by force causes unbearable pain.

Fig. 146.—x-Ray of a Normal Hand and Wrist-joint. The radius and ulna have been outlined in white; the carpal bones in black. U, Ulna; R, radius; P, pisiform; CF, cuneiform; SL, semilunar; SP, scaphoid; TM, trapezium; T, trapezoid; OM, os magnum; U, unciform.

Anterior dislocation of the semilunar bone should be recognized clinically, even without the *x*-ray, by association of the following symptoms, viz.: (*a*) The history of an injury of considerable violence to the extended or twisted wrist; (*b*) a silver-fork deformity, the posterior prominence of which corresponds with the head of the os magnum, and between which and the lower end of the radius is found a groove representing the position formerly occupied by the now anterior dislocated semilunar bone; (*c*) a tumor under the flexor tendons of the wrist, just anterior to the lower end of the radius; (*d*) a shortened appearance of the palm as compared to the other hand; (*e*) stiffness of the partially flexed fingers, motion of which, either active or passive, is painful; (*f*) the persistence of the normal relation of the styloid processes of the ulna and the radius, and the existence of shortening of the distance from the radial styloid to the base of the first metacarpal.

Diagnosis.—The patient usually gives the history of a fall upon the wrist in the same manner as in the injury which usually causes a Colles' fracture. He has supposed that he has sprained his wrist, and for a few days has suffered severe pain and tenderness and has been unable to use the hand for ordinary purposes. Gradually he has been able to take up his work again, but after a certain time the soreness, tenderness, and disability have refused to improve, and perhaps he has suffered some similar injury a second time, and the symptoms have become aggravated again. Examination shows that the fingers have their normal flexibility, but that the active and passive motions of the wrist-joint are limited to one-half or less of their normal excursion arc. Attempts to continue passive motion beyond a certain point, especially in extension, are limited by a most characteristic muscle spasm very similar to that seen in tuberculous joints. If the spasm is overcome by force and the wrist moved still further, the pain is intolerable. There is no crepitus or ecchymosis, but there is seen to be slight swelling or thickening over the radial half of the wrist-joint. The outlines of the extensor tendons of the thumb are made less distinct by the swelling, and pressure elicits signs of tenderness definitely localized over the scaphoid bone, and especially in the anatomic snuff-box. The *x*-ray shows a transverse fracture in the scaphoid.

Fig. 147.—Wrist-joint and Hand in Boy of Ten.

Fig. 148.—Wrist-joint and Fingers in Child of Five.

As compared with the other wrist, a certain amount of alteration of the bony landmarks is found. The relation of the ulnar and radial styloids is, of course, normal, but when the wrist is flexed, the prominence formed by the scaphoid just below the lower end of the radius is more pronounced than that of the other wrist and feels quite differently. This difference is, however, not striking enough to form the basis for a diagnosis unless taken with other symptoms. Treatment with counterirritants, massage, rest, forced motions under anesthetics, etc., fails to bring about any considerable improvement in the condition, and function of the wrist remains permanently, though not greatly, impaired.

In the majority of the cases of Codman and Chase the fracture had occurred at almost exactly the middle of the scaphoid, but in five cases it occurred at the junction of the middle and proximal thirds. The tenderness in all cases was very characteristic, being definitely localized in the scaphoid bone itself, and being especially acute in the anatomic snuff-box. If, in an uninjured adducted hand, the thumb of the examiner be pressed just below the styloid process of the radius in the anatomic snuff-box, the patient will feel an acute tenderness from the pressure on a branch of the radial nerve against the scaphoid bone. This "normal tenderness" is, however, bearable even if great pressure is made. On the other hand, if the scaphoid is broken, even if the injury occurred many years before, the tenderness in the snuff-box will be too great to be borne without wincing, and the patient will usually try to withdraw his hand. As a matter of fact, when the wrist is adducted and pressure made in the snuff-box, the point touched is almost exactly the middle third of the bone where the fracture occurs. Although the tenderness is most marked in the anatomic snuff-box, there is often found, in old cases, tenderness over the dorsal portion of the scaphoid. Tenderness in this region is, however, much less acute, and is scarcely more noticeable than in the other portions of the wrist.

The swelling in both the acute and old cases is in very much the same distribution as the tenderness, being more distinct on the radial half of the wrist, and especially about the tendons bounding the snuff-box. There is usually but little swelling, but on comparison with the other wrist, there is no difficulty in seeing it. Immediately after the injury there is usually a great deal of swelling of the wrist and dorsum of the hand, so that the diagnosis may be found more difficult than in old cases where the tenderness and swelling are more definitely localized in the scaphoid region. In no case was crepitus or ecchymosis found, although in a few cases the patients themselves have said that the wrist was black and blue soon after the injury.

Cases of sprained wrists, which have been shown by the x-ray to have no fracture, have recovered promptly—that is, within a few weeks; therefore in the diagnosis from sprain, besides the local tender extensor spasm, the persistence of the symptoms speaks strongly for fractures of the scaphoid. In fracture or fissure in the lower end of the radius careful palpation will almost invariably show that the maximum point of tenderness is at the lower end of the radius and not over the scaphoid. Another point which may assist in this diagnosis is the sudden appearance of fluctuation in the common bursa or sheath of the tendons of the extensor carpi radialis brevior and longior and extensor secundi internodii pollicis. As a result is a tense, fluctuating swelling of rather triangular shape, overlying the radial half of the wrist-joint, and extending somewhat up on the lower end of the radius on its dorsal aspect.

Codman has come to regard the presence of the engorged bursa immediately after an injury to the wrist as diagnostic of a fracture or fissure of the lower end of the radius. In making the diagnosis of fracture of the scaphoid as distinct from Colles' fracture, one must not forget that the two lesions may coexist.

In the cases which present themselves long after the injury, confusion with the different forms of arthritis is apt to arise in making the diagnosis. In fact, in such cases the natural diagnosis, unless the history of the injury is definitely stated by the patient, would be osteo-arthritis. Against this diagnosis, however, we usually find the evidence of this disease. Careful questioning will bring out the history of a definite injury. Then, too, examination invariably shows the characteristic tenderness in the snuff-box and spasm upon forced extension of the wrist. In two cases Codman at first confused the lesion with tuberculosis of the wrist, but the absence of the history of the injury and the presence of the local heat, the character of the spasm, and, finally, the location of the tuberculous focus by the *x*-ray, served to make the diagnosis.

Diagnosis by the *x*-ray alone should be made with the utmost caution, and only considered positive when a good view of the bone at right angles to its long axis is obtained. A practical way to obtain a good picture of the scaphoid is to place the two wrists of the patient in adduction and to place the tube in a position over the middle between the two hands, as far forward as the level of the knuckles.

Dwight,[43] in a recent article, states that the scaphoid is developed from a radial and an ulnar element. He believes that the majority of the cases called fractures of the scaphoid are due to the separation of the two original parts. In some individuals the scaphoid may remain separated throughout life as a persistence of the embryonal condition.

Treatment.—If the patient is seen immediately after the injury, it is possible, by fixation of the joint for a proper period, to obtain union. If, however, the wrist is not fixed during the first three weeks after the injury, union does not occur and the fracture remains permanently ununited. If the fracture remains ununited, the permanent disability is so great that it seriously interferes not only with the comfort of the patient, but with his ability to enjoy certain games and sports, and also, in the case of workingmen, it limits their working capacity, and hence their ability to earn their living.

In recent fracture we should endeavor, by fixation for a number of weeks, to obtain union before resorting to excision. At just what time after the injury the effort to obtain union by fixation should be abandoned is a very delicate question. After a fixation of four weeks we should resort to massage, etc., for another four weeks, and if, at the end of this time, there was no encouraging improvement in function and the x-ray showed no signs of union, we should advise operation. We should at once recommend excision of one-half or both halves of the bone. If operation is refused, the best treatment is merely to guard against further injury and, by limiting the use of the joint, to endeavor to avoid a chronic arthritis. Many patients have felt relief by wearing a leather wristlet, but this has produced no essential improvement. The operation for removal of the proximal fragment of scaphoid bone, which Codman and Chase have devised, is quite simple and easy of execution either under cocain or ether. An incision one-half inch long is made on the dorsum of the wrist, just to the inner side and parallel to the border of the extensor carpi radialis longior tendon. The wound is held apart with retractors, and an incision of about the same length in the same line made through the annular ligament in the fibrous septum between the long extensors of the fingers and the long extensors of the wrist.

Very slight passive motion is begun within a week in order to prevent adhesions, and by the end of two weeks entire removal of the splints and both active and passive motion of the joint are permitted. The use of the fingers may be allowed at the end of a week.

FRACTURES OF THE METACARPAL BONES.

Fracture of the metacarpal bones was formerly considered to be an infrequent occurrence. The routine use of the x-ray in many cases

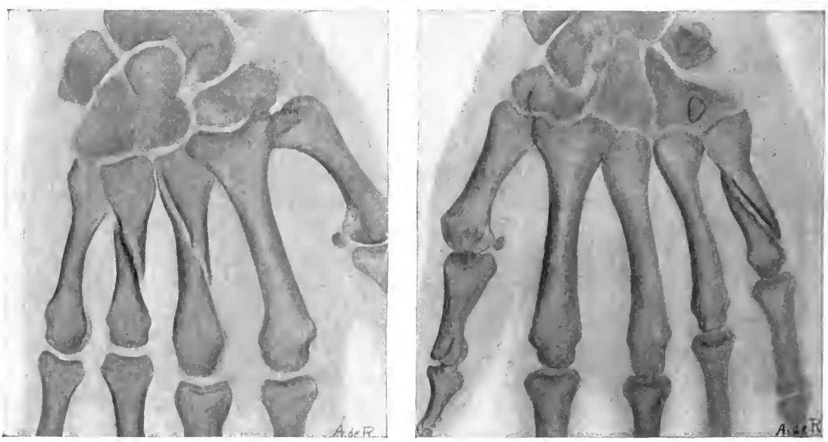


FIG. 149.—FRACTURES OF THE METACARPAL BONES.
Made from x-ray pictures (after Schlatter).

of injury to the hand has shown that such is not the case. Bennett,[44] of Dublin, first directed attention to the occurrence of a fracture through the base of the metacarpal bone of the thumb, and this form is called Bennett's fracture. Since this time a number of articles have appeared by Miles and Struthers,[45] Schlatter,[46] Russ,[47] Beck,[48] and others showing that fractures of all the metacarpal bones are quite common, but often overlooked. Miles and Struthers report a series of 15 cases of the injury known as Bennett's fracture.

In the majority of cases the seat of fracture in metacarpal fractures is in the middle of the bone. Schlatter reported 21 cases and Russ 27 cases. The different forms according to the line of fracture are: (*a*) Transverse; (*b*) spiral; and (*c*) fissured or longitudinal. The transverse form is usually the result of direct violence, such as a crushing force or a blow upon the hand. This form is most apt to involve the second and third metacarpal bones. The spiral variety is more frequent in the outer half of the hand. Of 10 cases of the spiral form observed by Schlatter, 5 were in the fifth, and the remainder in the third and fourth, metacarpal bones. A twisting force, such as a fall upon the fingers, is most apt to cause a spiral or torsion fracture.

In Russ' series of 27 cases, the first and fifth metacarpals were involved in nearly 60 per cent. of the cases. Epiphyseal separation may also occur in the metacarpal bones.

Carl Beck[48] has called attention to a type of metacarpal fissure. It is the result of indirect violence, such as a blow while the hand is clenched or a fall upon the knuckles.

With the exception of the transverse variety, there is but little displacement in metacarpal fractures. There may be an angular deformity present, with its apex toward the dorsum or palm of the hand.


FIG. 150.—FRACTURE OF METACARPAL BONE OF LITTLE FINGER.

The most typical displacement is that occurring in the so-called Bennett fracture, *i. e.*, close to the base of the first metacarpal bone. The fracture being an oblique one, the shaft is displaced backward and upward so as to lie behind the trapezium, resembling somewhat a subluxation of the metacarpal bone in this direction. Should the fracture be overlooked, union takes place with a deformity which interferes with the movements of the thumb.

Diagnosis.—In Bennett's fracture the presence of the above-described deformity, when associated with abnormal mobility, crepitus, and pain close to the base of the metacarpal bone of the thumb, will usually enable us to make a diagnosis without the use of the x-ray. These signs of fracture are best elicited by extending the thumb, while the seat of fracture is grasped by the fingers of the other hand of the examiner.

The presence of a fracture in the other metacarpal bones must be suspected from the pain and loss of function, especially upon attempting to extend or to flex the fingers.

At times the displacement of fragments, especially if it is angular, can be readily palpated. In the majority of cases the ordinary signs of fracture are obscured by the swelling. A skiagraph should therefore be taken in every case of severe contusion of the metacarpal region.

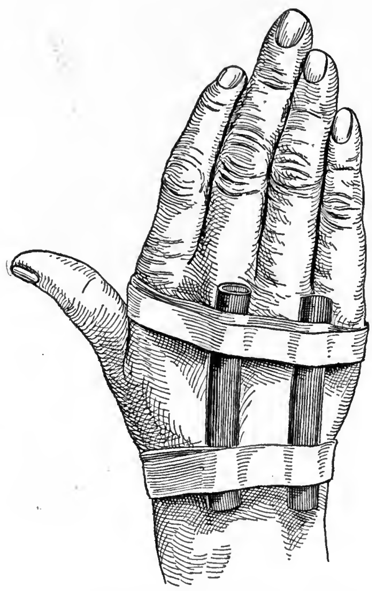


Fig. 151.—Fracture of the Fourth Metacarpal Bone, Showing the Rubber-tube Splints in Place (Beck).

Abnormal mobility and crepitus can be elicited in some cases by alternately flexing and extending the fingers, while the suspected bone is grasped between the index-fingers and thumbs of both hands of the examiner which have been placed upon the back and front of the hand respectively.

In many of the cases the diagnosis cannot be made unless a skiagraph be taken. In fractures close to the metacarpophalangeal joints the lesion can be distinguished from a dislocation at this joint by the fact that the deformity is further back in a fracture; there is usually crepitus present and the joint movements are free.

Treatment.—In Bennett's fracture the displacement can be corrected by making traction on the thumb in the abducted and fully extended position, at the same time making pressure over the dorsal aspect of the trapezium. The best splint is a palmar one, extending from the tip of the thumb across the base of the hand beyond the ulnar side of the wrist. The distal end of the splint is fixed to the end of the thumb by adhesive plaster. The thumb is bandaged to the splint in an abducted and extended position.

The patient can be allowed free use of the thumb five weeks after the injury.

In fractures of the other metacarpal bone a deformity can be corrected by traction and pressure.

The hand and forearm are then secured to a well-padded palmar splint by strips of adhesive plaster. If the displacement tends to recur, the fragments can be held in place by rubber tubing or a slate-pencil

(Fig. 151), as recommended by Beck. In fractures close to the metacarpophalangeal joint extension can be secured by applying adhesive strips to the corresponding finger and fastening them to the end of the splint with the aid of rubber tubing.

Fractures of the Phalanges.—Our knowledge of these fractures has also greatly increased since the use of the *x*-ray. They can be divided into those of the shaft and those of the articular surface. In those of the shaft the line of fracture is either transverse or irregular. Among the latter may be mentioned the oblique Y or comminuted forms. Transverse and irregular fractures are usually the result of direct violence, such as a crushing force, and hence are often compound. They may be also due to indirect violence, such as a fall upon the finger. The

Fig. 152.—Anteroposterior and Lateral x-Ray View of Fracture of the Shaft of the Second Phalanx of the Middle Finger in a Girl of Eight.

articular fractures are usually the result of indirect force, such as a fall upon the finger. It is very apt to lead to stiffness or ankylosis of the adjacent joint. A third variety of fracture of the phalanges has been described, viz., a longitudinal or fissured form, due to a blow or a fall upon the finger, especially upon the distal phalanx.

Diagnosis.—In compound fractures the diagnosis can be readily made by the examination of the wound, taken in conjunction with the ordinary signs of fracture. In simple or closed fractures crepitus and abnormal mobility can often be easily obtained by grasping the phalanx with the fingers of the examiner and moving it to and fro. In the transverse variety of fractures of the shaft there is usually some rotation of the distal fragment, or hyperextension with lateral deviation, according to Schulz,[49] whose article is the most complete upon this subject.

In the **Y**, oblique, and comminuted fractures of the shaft the finger is always broader and thicker. Abnormal mobility and crepitus are much less marked than in the transverse form. They occur more frequently than the latter form.

The diagnosis can often be made without the use of the *x*-ray. In the articular fractures the joint is broader or thicker. An example of this is the base-ball finger. The distal end of the finger often shows lateral deviation, and there is more or less limitation of motion on account of the swelling and pain. The fissured fractures can be recognized only by the use of the *x*-ray, unless the phalanx is broader and is painful.

Treatment.—It is impossible to reduce the fragments in the articular forms on account of their small size. Great care should, however, be employed to begin massage and passive motion at the end of the third week, in order to prevent ankylosis.

For the treatment of this and the other varieties of fractures of the phalanges, a palmar wooden, metal, or molded plaster-of-Paris splint, extending from a point just distal to the finger to the wrist, will be found most useful. If any displacement exists, it can be corrected by traction and countertraction. The splint, after being well padded, is held in place by adhesive strips applied in a circular manner. Rotation or lateral deviation of the distal fragment is especially to be guarded against.

The prognosis in simple or closed fractures of the shaft is much better than in the articular variety, owing to the danger of ankylosis in the latter.

Compound or open fractures demand the most scrupulous attention to asepsis. If the disinfection is painful, it is best to administer an anesthetic in order to be thorough. No field of accident surgery offers better rewards for conservatism than compound fractures of the phalanges. Amputation should only be resorted to after every effort has been made to preserve the finger by the use of wet antiseptic dressings, etc.

FRACTURES OF THE PELVIS.

Fractures of the pelvis may be divided into:

1. Those which involve the pelvic girdle as a whole.
   (*a*) Separation of the symphysis pubis.
   (*b*) Fracture of the horizontal and ascending rami of the pubes.
   (*c*) Vertical (single or double) fractures of the lateral portions, *e. g.*, the ilium passing through the acetabulum.
2. Those which involve individual bones.
   (*a*) Fractures of the expanded upper portion of the ilium.
   (*b*) Fractures of the rim of the acetabulum.
   (*c*) Fractures of the ischium, sacrum, and coccyx.

Of the above, the commonest are those in which the rami of the pubis or the alæ of the ilium are broken. The remaining ones are very rare. Fractures of the rim of the acetabulum resemble dislocation of the hip so closely that they will be considered under the Injuries of the Hip.

Fractures of the crest of the ilium, of the anterior superior spine of the ilium, transverse fractures of the sacrum or coccyx, and some of the fractures of the pubes are due to direct violence, such as a blow or a fall from a height or a fall upon the perineum with the limbs apart.

In fractures due to indirect violence, usually the result of a crushing force, the favorite seat is in the descending ramus of the pubes and the ascending ramus of the ischium. In all the more severe cases the fractures are either unilateral or bilateral. If the latter is the case, they are often symmetric. It frequently occurs that fractures of the front half of the pelvis are accompanied by similar fractures of the posterior half, according to Stolper.[50] He believes that separations of the sacro-iliac joints either do not exist or are very rare. Fractures through the lateral masses of the sacrum or through the sacral foramina are, however, often present (Fig. 153). A fracture in which the head of the femur

Fig. 153.—Location of Frequent Fracture Lines in Fracture of the Pelvis. Those on the anterior portion of the pelvis are bilateral, while the posterior ones are unilateral.

is driven through the acetabulum occurs, but is very rare. (See chapter upon Dislocation.)

A dislocation or diastasis at the symphysis pubis is also infrequent, but does unquestionably occur. A frequent combination is that of a fracture of the crest of the ilium with those of the pubic or ischial rami or of the sacrum in the typical places (Fig. 153).

In some cases a marked displacement of fragments occurs. Callus-formation is at times so excessive that it can be felt externally.

Diagnosis.—For diagnostic purposes fractures of the pelvis are best divided into—(*a*) Those complicated by visceral injury, and (*b*) those not accompanied by such a lesion. The possibility of a fracture of the pelvis with or without visceral complications must always be thought of in examining a patient who has been subjected to a crushing force, such as being run over, caught between buffers, etc. In the more severe cases there is usually considerable pain and shock at the time of injury. In the less severe forms the pain and shock are often so slight that the fracture is either overlooked, or there are no symptoms until the patients attempt to get up. In fractures involving the alæ or crest of the ilium one should carefully palpate the entire bone, wherever accessible, for deformity and localized pain. By placing one hand upon each side of the pelvis and pressing both iliac crests gently together one can at times find crepitus and abnormal mobility. In fractures of the pubic or ischial rami, as well as in cases of deep-seated fractures of the ilium, pressure backward upon the anterior spines will cause considerable pain. After this, pressure from behind should be made upon both crests. The patient will indicate where the pain is located, and one can confirm the seat of the pain by direct pressure. Palpation of other parts of the pelvis is usually negative unless a considerable displacement exists. Usually there is but little displacement, so that the diagnosis must be made from the accompanying visceral injuries. A rectal examination should never be omitted in doubtful cases and will often enable us to make an exact diagnosis. The x-ray is of but little aid.

FIG. 154.—TYPICAL LOCATIONS OF LINES OF FRACTURE IN FRACTURES OF THE PELVIS.

Note the line of fracture passing through the horizontal ramus of the pubis, and a second at the junction of the descending ramus of the pubis and ascending ramus of the ischium. The posterior fracture lines pass through the ilium in a Y manner, terminating in the greater sciatic notch.

The **complications** of a fracture of the pelvis are: (*a*) Wounds of the overlying skin and muscles; (*b*) lacerations of the adjacent nerves and blood-vessels; (*c*) rupture of the urethra and bladder. In addition to these there may be serious injuries of the other abdominal viscera or of the thoracic viscera or ribs, spine, skull, and brain. Injury of the skin is quite rare. The blood-vessels which are most frequently torn are the common iliac, the superior gluteal, internal pudic, and obturator arteries and veins. Thomas Bryant has reported three cases of thrombosis of the external iliac artery. There is always danger of pulmonary embolism due to a thrombus detached from one of the larger pelvic veins.

Severe nerve injury only occurs in a fracture of the coccyx. Injury

Fig. 155.—Posterior View of Pelvis Showing Bilateral Fracture.
The line of fracture on the right side passes into the acetabulum.

of the bladder or urethra or a rupture of both of these structures is most apt to occur in a fracture around the symphysis (Fig. 157). The bladder is less often injured than the urethra.

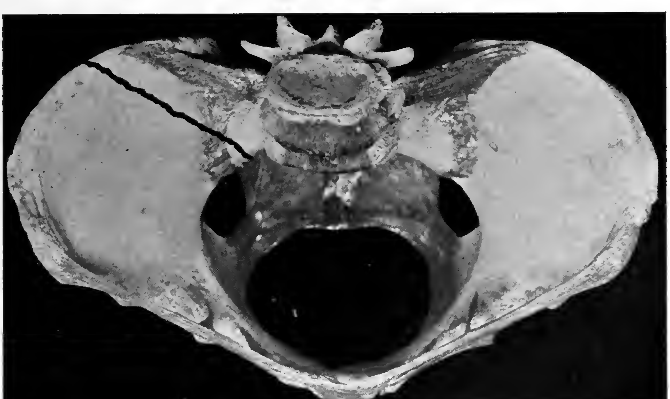


Fig. 156.—View of Pelvis from Above.
Showing a frequent line of fracture, passing through the posterior portion of the ilium, across the sacro-iliac joint, into the sacrum.

A rupture of the bladder is usually of the intraperitoneal variety, and is either due to the original injury or to a displacement of fragments or to its being penetrated by a splinter of bone.

The most prominent symptoms of injuries of the bladder or urethra are hematuria, difficulty in urination, and retention. In a rupture of the urethra, if the patient is able to urinate, he can do so only with great difficulty, and the act of urination is accompanied by pain. The amount voided is small, and considerable amounts of coagulated or liquid blood escape from the urethra. If an effort be made to pass a metal catheter, it will be caught in the membranous portion of the urethra, if the tear in the latter is a complete one. If the tear is incomplete or the bladder be torn, it will be possible to pass the catheter through the entire urethra easily. If the case is seen twenty-four to forty-eight hours after the injury, the scrotum and perineum are swollen and there are evidences

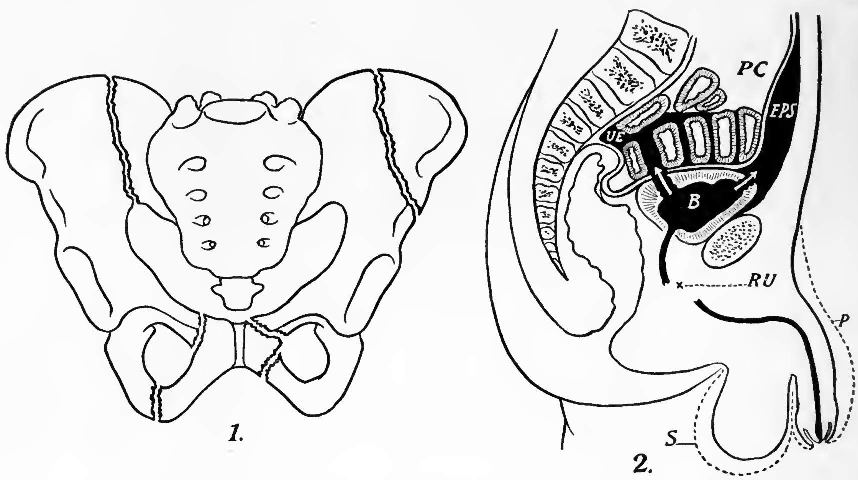


Fig. 157.—Varieties of Fractures of the Pelvis and Most Frequent Complications.

1, Shows the most frequent lines of fracture of the pelvis (see text); 2, shows the three most frequent complications of fractures of the pelvis; *RU*, rupture of urethra associated with extravasation of urine into the scrotum (*S*) and penis (*p*); *B*, bladder. The arrow upon the anterior wall indicates an extraperitoneal rupture of the bladder with extravasation of urine into the extraperitoneal cellular tissue around the bladder and between the peritoneum and anterior abdominal wall (*EPS*). The arrow situated upon the posterior wall and the fundus of the bladder indicates the escape of urine through an intraperitoneal tear into the free peritoneal cavity. The black area (*UE*) indicates the urine escaping between the coils of intestine into the general peritoneal cavity (*PC*).

of beginning septic intoxication from the infiltration of the tissues with urine.

In an intraperitoneal rupture, in addition to the dysuria, retention, and hematuria, the metal catheter can be passed into the bladder unless there is an accompanying tear of the urethra. If the bladder alone is torn, a very small quantity of bloody urine is obtained through the catheter.

The test formerly employed, of filling the bladder with a measured quantity of sterile water, is very apt to lead to erroneous conclusions. In some cases the first suspicion of a rupture of the bladder is the onset of signs of peritonitis, accompanied by rapidly increasing dullness in the lower part of the abdomen. A diagnosis could, however, have been made during the first twenty-four hours if attention were paid to the difficulty in urination, retention of urine, and hematuria. In this connection it is well to remember that some of these symptoms may be present in a paralysis of the bladder sphincters as the result of injury.

In extraperitoneal tears of the bladder dysuria, retention, and hematuria are also present, but there is, in addition, a rapidly increasing area of dullness above the pubes or signs of beginning infiltration of the skin and subcutaneous tissues.

Prognosis and Treatment.—Unless a diagnosis is made at an early period, the prognosis of cases of fracture of the pelvis accompanied by visceral injury is very grave. If the symptoms point to a rupture of the urethra, an external urethrotomy should be performed as soon as possible, the proximal end of the urethra looked for, and a catheter passed through the entire length of the urethra. If, after a diligent search, the proximal end cannot be found, retrograde catheterization can be performed.

If there is suspicion of a rupture of the bladder, the tear should be looked for through a suprapubic incision. If it is intraperitoneal, a purse-string or Lembert suture is inserted. If the tear is extraperitoneal, the rent can be closed in a similar manner and a suprapubic drain inserted. Injuries of other abdominal viscera must always be thought of in connection with fractures of the pelvis. In cases not complicated by visceral or urethral injury union will occur in four to six weeks if the patient is kept quiet in bed. Pain should be relieved by opiates. The pelvis can be supported by a wide muslin binder passed around it, the knees being fastened together. The patient should not be permitted to leave his bed for six to eight weeks. No effort should be made to reduce the fragment.

The patient should either be placed upon an air-bed or can be raised by means of a Bradford or Verity frame, made of cast iron and following the outlines of the body.

INJURIES IN THE VICINITY OF THE HIP-JOINT.

In the examination of a patient as to the nature of an injury in the vicinity of the hip, the conditions to be thought of vary somewhat in adults and children.

In adults they are: (*a*) Fractures of the head and neck of the femur; (*b*) fractures of the acetabulum; (*c*) isolated fracture of the greater or lesser trochanter; (*d*) dislocation of the hip; (*e*) contusion or sprain of the hip.

In children and young adults the lesions to be especially considered are: (*a*) Fracture of the neck of the femur; (*b*) epiphyseal separation. The relation of traumatic coxa vara to these injuries in children and adolescents is considered on p. 237.

The examination, when conducted in a systematic manner, will enable us to make a diagnosis in the majority of cases without a skiagraph. The latter method should, however, be employed as a routine measure in every case. Satisfactory skiagraphs of the hip region are difficult to obtain unless the operator has had considerable experience. The use of the focussing tube of Albers-Schoenberg is of great service in this direction.

The chief points to be determined are the following:

(*a*) The position of the limb, especially whether internal or external rotation be present.

(*b*) The degree of shortening as determined by measurement of the length of the limb in the manner shown in Fig. 159. A steel tape-measure is stretched from the anterior superior spine of the ilium across the middle

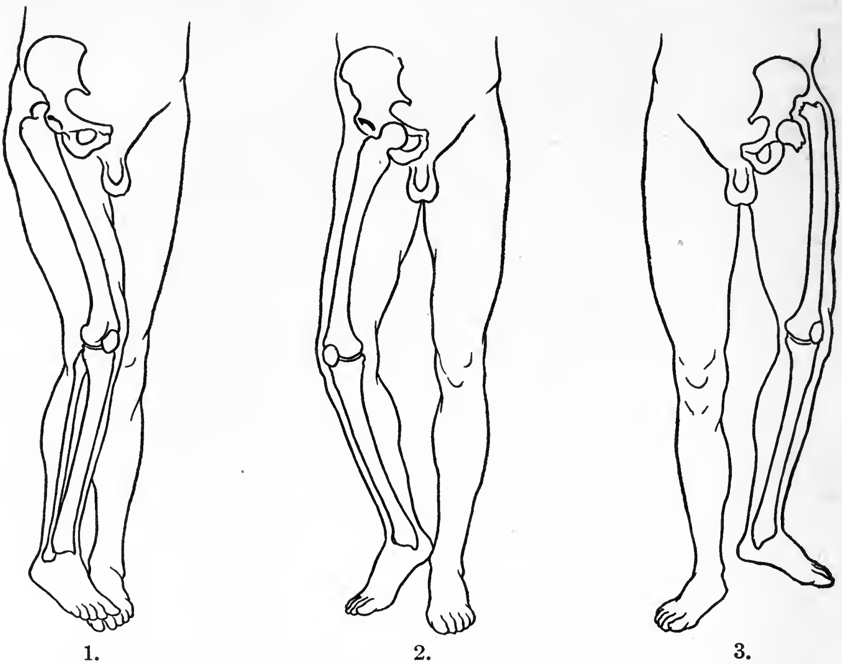


Fig. 158.—Most Frequent Conditions to be Considered in Differential Diagnosis of Injuries of the Hip-joint.
1, Backward and upward dislocation of the head of femur; 2, forward dislocation of head of femur; 3, fracture of neck of femur.

of the patella to the lower border of the inner malleolus. A similar measurement is made of the opposite limb. Both limbs should be adducted to the median line and be fully extended, and the anterior superior spines should be at the same level during this measurement. Instead of beginning the measurement at the anterior or superior spine, Keen believes that a more accurate method is to begin at the lower end of the inner malleolus. (*c*) The relation of the greater trochanter to the Roser-Nélaton line is next determined as shown in Fig. 160. A steel tape-measure is stretched from the anterior superior spine of the ilium to the tuberosity of the ischium, the lower edge of the tape passing normally along the upper border of the trochanter.

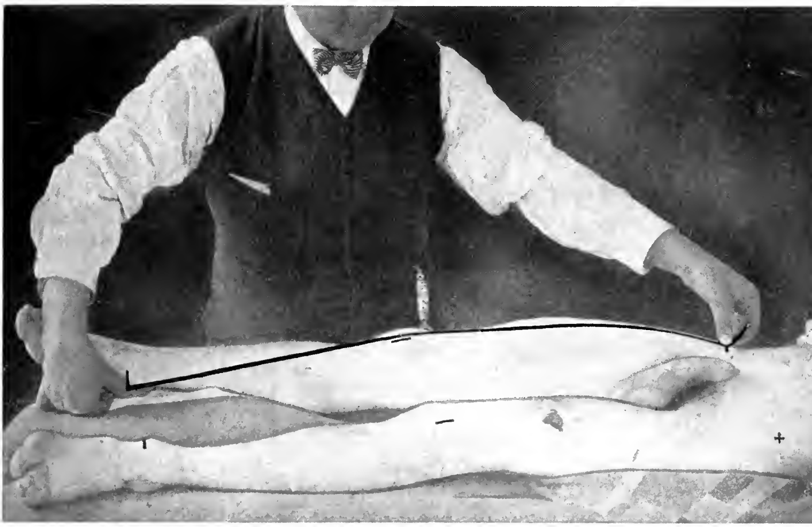


FIG. 159.—METHOD OF MEASURING THE LENGTH OF THE TWO LIMBS IN A CASE OF FRACTURE OF THE SHAFT OR OF THE NECK OF THE FEMUR.

While the patient is lying upon his back, three points should be marked on each limb, as shown in the illustration, namely, the anterior superior spine of the ilium, the middle of the patella, and the lower border of the inner malleolus. There may be apparent shortening due to the elevation of the pelvis, as shown in the illustration. The method of measurement consists in placing one end of a steel tape-measure on the anterior superior spine, and the other across the line drawn just below the inner malleolus. The tape-measure should pass exactly through the line drawn in a vertical manner through the middle of the patella. In the illustration this latter line has been purposely shown a little to the inner side of the tape-measure. The outward rotation of the limb in fractures of the shaft of the femur is well shown in this patient.

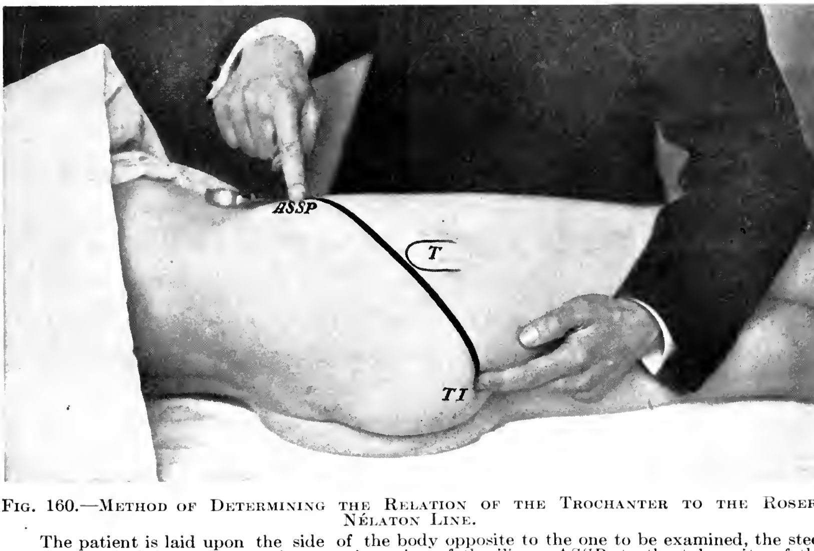


FIG. 160.—METHOD OF DETERMINING THE RELATION OF THE TROCHANTER TO THE ROSER-NÉLATON LINE.

The patient is laid upon the side of the body opposite to the one to be examined, the steel tape is stretched from the anterior superior spine of the ilium, *ASSP*, to the tuberosity of the ischium. These two points are fixed by the index-fingers of the two hands, preferably those of an assistant, while the examiner marks the lower level of the tape as it crosses the upper border of the trochanter. Under normal conditions the tape should pass exactly along the upper border of the trochanter.

Under normal conditions the latter point should be in or a little below the Roser-Nélaton line. The same measurement should be taken upon the healthy side and the two results compared. (*d*) a fourth step is to determine the measurements of the Bryant triangle (Fig. 161). This is done by dropping a steel tape from the anterior spine of the ilium to the table or bed upon which the patient rests, and marking the position of the lower border of the tape upon the patient's gluteal region in ink. A thin wooden rod held against the side answers the purpose even better. The distance of the upper border of the greater trochanter from this vertical line is now measured and compared with a similar measurement taken on the opposite side. In the normal adult this horizontal distance is $2\frac{1}{2}$ inches (6.25 cm.). (*e*) The limb should now be gently manipulated. Great care should be exercised not to break up any impaction. By grasping the hip in the manner shown in Fig. 165 and rotating the limb, one can determine the presence or absence of abnormal mobility, crepitus, etc. The interpretation of the results obtained by these various manipulations can be best considered under the head of the individual injuries of this region. In cases where no impaction exists, much information can be gained by the administration of an anesthetic to relax the muscular spasm.

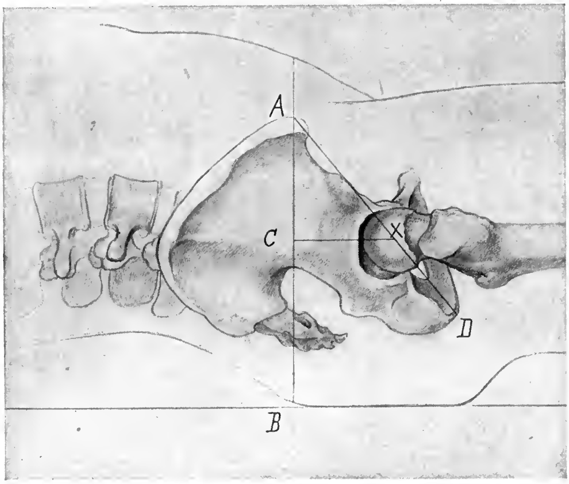


Fig. 161.—Bryant's Triangle.

A C X, Bryant's triangle. Distance (X C) from top of trochanter to perpendicular (A B) dropped from anterior spine to horizontal table top is Bryant's measurement. After fracture this measurement may be less than normal (Scudder).

Fractures of the Head and Neck of the Femur in Adults.—Only three positive cases of fracture of the head have been reported. The case reported by Riedel (quoted by Hoffa[51]) resembled a backward dislocation of the hip, and operation revealed a splitting of the neck and head longitudinally. Fractures of the neck of the femur in adults usually occur beyond the age of fifty. After seventy they constitute one-third of all the fractures at this period of life. It is more common in women than in men. The occurrence of the same injury in childhood and adolescence is described separately on p. 237. The chief reason for the frequency of fractures of the femoral neck in elderly people is the atrophy or osteoporosis which occurs in all parts of the osseous system, but is especially marked at the neck of the femur. The cortex becomes much thinner and the meshes of the cancellous tissue are greatly enlarged. It was formerly believed that a change occurred in the angle which is formed by the neck with the shaft, and that this favored fracture at this point. It was thought that the angle, which is normally about 129 degrees, more nearly approached a right angle in elderly people, but it has been found that the difference between the angles in adults and old people is so slight as to have no influence upon the predisposition to fracture.

Causes.—The most frequent cause is a slight injury, such as a misstep or a fall upon the floor while walking, or a fall upon the trochanter. The strain exerted through the ligaments in extreme positions of the limb is a more frequent cause of fracture than is generally supposed (Stimson, Linhart, and Riedinger). Fractures of the neck of the femur are usually divided into—(*a*) Fractures through the neck, *i. e.*, at the junction of the head and neck, and (*b*) fractures at the base of the neck. To the former the term *intracapsular*, and to the latter the term *extracapsular*, fracture is often applied. It is of little consequence, from a clinical standpoint, as to whether the fracture is intracapsular or extracapsular, hence these terms are being dropped by the majority of writers. Kocher has suggested calling a fracture at the junction of the head and neck *fractura subcapitalis*, and a fracture through the base of the neck *fractura intertrochanterica*, but these terms have been but little used by other surgeons.

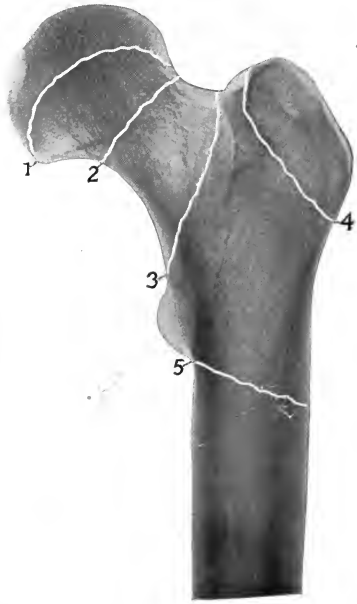


Fig. 162.—Location of Most Frequent Fracture of Upper End of Femur.

1, Epiphyseal separation; 2, subcapitalis, at junction of head and neck; 3, junction of neck and shaft; 4, of great trochanter; 5, subtrochanteric through upper third of shaft.

The chief value of knowing clinically the exact position of the seat of fracture is from the standpoint of prognosis and treatment. Both of these will be referred to later. It may be stated here that non-union is far more likely to occur, and is almost the rule in fractures at the junction of the head and neck. This is due to the fact that if the periosteum of the neck is extensively torn, the only source of nutrition for the head is through the ligamentum teres, and but little if any callus-formation takes place from the head fragment. Usually the periosteum remains untorn over a portion of the periphery. If the separation of fragments is great, it may be completely torn, and this will greatly affect the prognosis.

In fractures through the base of the neck the line of fracture follows the junction of the shaft and neck quite closely. In the majority of cases other lines of fracture traverse one or both trochanters.

Fractures at the junction of the head and neck are rarely impacted, while in those occurring at the base of the neck impaction is more frequent. In the latter variety of fracture the penetration or impaction is most marked in the posterior portion of the neck, causing eversion of the limb.

Penetration of the anterior portion of the neck with resultant inversion of the limb is infrequent. The degree of displacement varies according as impaction is present or not. If there is no impaction, the displacement is very slight in fractures through the neck, *i. e.*, at the junction of the head and neck. In non-impacted fractures at the base of the neck

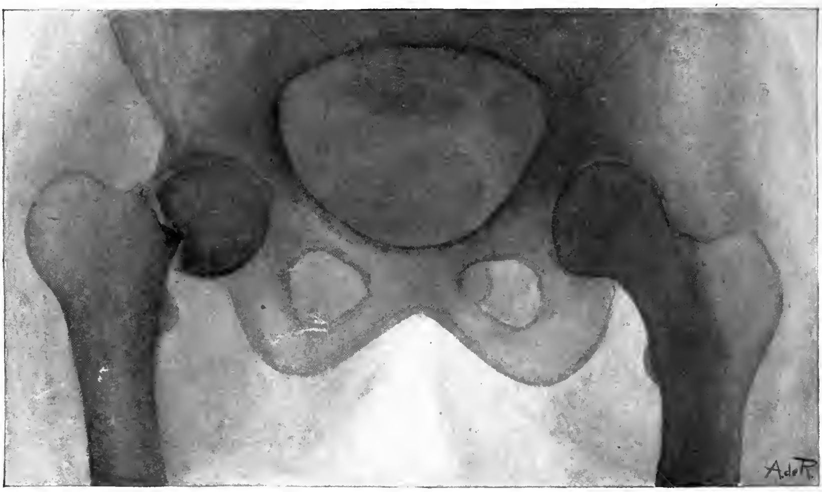


FIG. 163.—x-RAY OF A FRACTURE OF THE NECK OF THE FEMUR AT THE JUNCTION OF THE HEAD AND NECK, WITH UPWARD DISPLACEMENT OF THE SHAFT OF THE FEMUR.
On the opposite side note the outlines of the normal femur and hip-joint. This *x*-ray was kindly loaned by Dr. Le Moyne Wills.

the displacement is the same as in the first-named variety, but it is much more marked. The lower fragment is drawn up and everted. This gives rise to shortening of the leg, eversion, and the other objective signs of this fracture (see Diagnosis). Bony union is rare in fractures at the junction of the neck and head. Only 14 such cases have thus far been reported. In the majority of cases either non-union or a loose fibrous union results. The non-union is not due to the absence of coaptation of fragments, but is the result of the defective blood-supply to the upper fragment, on account of the tearing of the periosteum. Not infrequently the neck is absorbed and the lower fragment, *i. e.*, the shaft, slides up and rests upon the dorsum ilii. Union is much more likely to occur in non-impacted fractures at the base than in those at the narrow portion of the neck. In feeble individuals above the age of sixty union seldom occurs in fractures at either of these locations. The prospect of union in impacted fractures is quite good if the impaction is not disturbed by rough manipulation, or if the patient is not permitted to step upon the limb too early.

Diagnosis.—As was previously stated, it is of but little importance from the standpoint of diagnosis as to whether the fracture is intracapsular or extracapsular. The first question to answer is whether a fracture of the neck is present, and next whether it is impacted or not. The most important symptoms common to all fractures of the neck of the femur are:

1. Loss of function of the whole extremity.

2. Eversion of the limb.

3. Shortening of the limb.

4. Elevation of the trochanter.

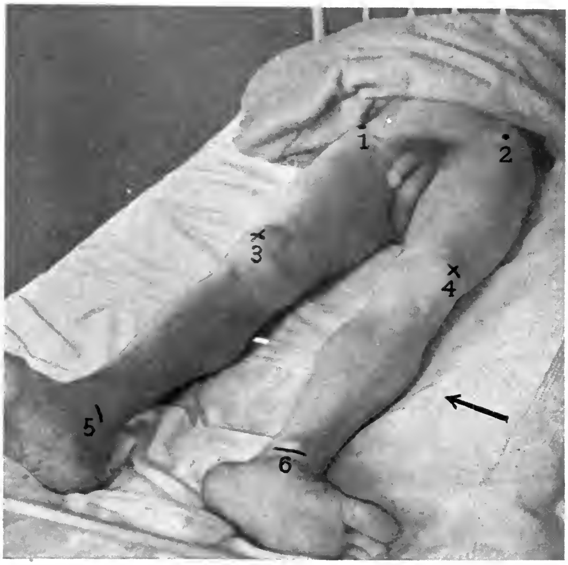


Fig. 164.—Eversion of Lower Extremity in a Case of Recent Fracture of the Neck of the Femur.

The arrow points to the markedly everted limb. 1 and 2, Anterior superior spines of the ilium; 3 and 4, placed on center of patellæ; note how the patella on the fractured side points outward; 5 and 6, marks placed on lower border of internal malleoli. The measurement of the limb for shortening should be made as shown in Fig. 159, from 2 to 6 on the fractured side, and 1 to 5 on the normal side, passing through the middle of the patellæ. The characteristic shortening of the limb can be observed by comparing the points 5 and 6, taking into consideration at the same time the elevation of the pelvis on the side of the injury.

1. *Loss of Function.*—The patient is, as a rule, quite helpless, but in some cases of impacted fracture the patient may have even been able to walk a few steps. Voluntary movements cause great pain referred to the hip. There is often great pain on pressure over the trochanter or over the front part of the hip. Loss of power is usually most frequent in fractures at the base of the neck. The patient is unable to rotate the limb inward.

2. *Eversion or External Rotation.*—The position assumed by the limb is quite characteristic (Fig. 164). The limb is completely everted, so that the outer border of the limb rests upon the bed. Inversion has been found in a few cases, but is quite rare. Eversion is only slight in impacted fractures, but is complete in the non-impacted variety.

3. *Shortening.*—The measurement of the length of the limb from the anterior superior spine to the inner malleolus (Fig. 159) will show a slight degree of shortening in the impacted cases. In non-impacted fractures

it varies from one to three inches. The maximum shortening in the latter variety of fractures is usually present at the time of injury. There are, however, cases in which the shortening is most marked a few days or even weeks after the injury. It must not be forgotten that in some individuals there is a normal difference of one-half to one inch in the length of the two limbs.

4. *Elevation of the Trochanter.*—Measurements of the relation of the trochanter to the Roser-Nélaton line and to the perpendicular in Bryant's triangle (Fig. 161) will show that the trochanter has moved upward. The amount of elevation is the same as that of the shortening of the limb. The other signs of fracture should not be sought until one has determined by gentle manipulation whether the fracture is

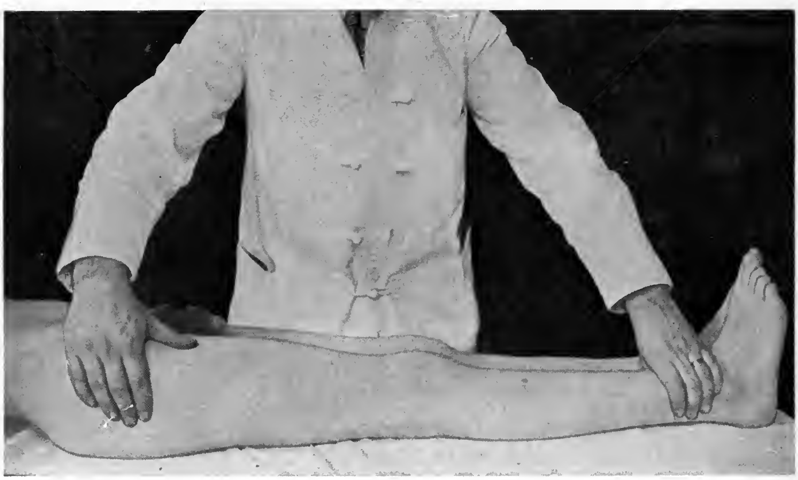


Fig. 165.—Method of Examination of the Lower Extremity for Abnormal Motion at Neck of Femur.

For photographic purposes it was necessary to have the examiner stand upon the left side of the patient. In practice in examining the right lower extremity the left hand should grasp the trochanter, the fingers placed upon the back of the latter, and the thumb upon its anterior surface. The right hand should be placed across the front of the ankle-joint. In examining the left limb, the order should be reversed, the right hand being placed over the trochanter, and the left over the ankle.

impacted or not. If not impacted, crepitus and abnormal mobility can be elicited by grasping the trochanter between the thumb and fingers, while an assistant gently rotates the limb (Fig. 165). The history of a slight injury, such as a misstep upon the carpet or a fall upon the trochanter, followed by immediate loss of function, and the age and sex of the patient, will often be of great service in the diagnosis. It can be made, in the majority of cases, without the aid of the x-ray or of an anesthetic. The latter is apt to cause so much muscular relaxation that an impaction is easily broken unless the limb be handled very gently, especially during rotation. Traction upon the limb will often show that the shortening can be corrected, but readily recurs. The only form of dislocation of the hip with which it could be confused is the forward variety. The absence of the head in the groin or obturator region and the presence of the characteristic signs described on p. 229 would soon exclude this injury. Inversion of the limb occurs so rarely in fractures of the neck of the femur that there is but little necessity of differentiating it from a backward dislocation of the hip. In the latter condition the toes of the injured limb rest upon the sound foot. The limb is moderately adducted, flexed, and markedly inverted. The head of the bone can be felt in the gluteal region, and there are no abnormal mobility and crepitus upon rotation of the limb. In a contusion of the hip, although there are evidences of contusion of the soft tissues over the trochanter, the limb is seldom rotated outward, there is no shortening, no elevation of the trochanter, and all movements of the hip-joint are free. In doubtful cases it is best to take an x-ray picture or give an anesthetic, care being used not to break up an existing impaction. The diagnosis of fractures of the hip in early life is considered separately (p. 238).

Fig. 166.—Treatment of Fractures of the Shaft of the Femur or of the Neck of the Femur by Means of a Plaster-of-Paris Body Cast (Davison).

Treatment.—The method of treatment to be adopted depends—(*a*) Upon whether the fracture is impacted or not and (*b*) upon the age and condition of the patient. In impacted fractures the best method is complete immobilization in the impacted position without attempting to correct the deformity. This is accomplished by the application of a plaster-of-Paris body cast as shown in Fig. 166, extending from the level of the umbilicus to the toes. Its weight can be greatly lessened and its strength increased by incorporating a number of strips of cypress wood, used for making strawberry boxes, between the layers of plaster at the hip and knee during the application of the cast. The patient is allowed to walk upon crutches, the sole and heel of the shoe upon the non-injured limb being raised three to four inches. If the patient is too old and feeble, it is best to place him upon a firm bed and prevent movements of the limb by sand-bags. A still better method for feeble patients is to place them upon a Verity frame made of gas-pipe which can be suspended from the ceiling and raised or lowered at will. In some cases of impacted fracture the Thomas hip splint (p. 169) will give excellent results.

No weight should be allowed to rest upon the injured leg for a period of three months. The limb must always be handled very gently.

In the treatment of non-impacted fractures the results have been so unsatisfactory that a number of different methods must be mentioned whose use varies according to the age and condition of the patient. These can be grouped as follows:

For old and feeble people who could not be kept in bed while using a retention apparatus one can employ:

1. The Thomas-Ridlon hip splint (Fig. 169).
2. A plaster-of-Paris body cast with or without abduction.
3. Rest in bed upon a Verity gas-pipe frame.

For those who are more robust or are able to remain in bed:

1. The Liston splint combined with Buck's extension.
2. The Ruth-Maxwell method of double traction.
3. The Hodgen splint.
4. Operative measures.

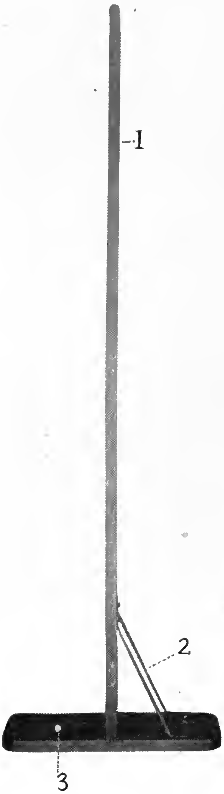


FIG. 167.—VIEW FROM ABOVE OF LONG EXTERNAL SPLINT FOR TREATMENT OF FRACTURES OF THE SHAFT OF THE FEMUR.

For measurements, see text. 1, Body-piece; 2, iron strips for securing better support of foot-piece; 3, opening through which rope for extension passes.

General Conditions.—If the patient is to remain in bed, it can be converted into a "fracture-bed" by inserting three heavy boards, each one foot wide, between the mattress and the frame of the bed. One board is placed under the shoulders, a second under the hip, and a third at the level of the knees.

These prevent sagging of the mattress. External rotation should be corrected and shortening overcome by traction upon the limb at the knee and ankle. Bedsores can be best guarded against by keeping the draw-sheet smooth and well stretched. The back should be kept thoroughly clean, rubbed with alcohol every day, and dusted with talcum powder. The pulse and temperature should be watched for pulmonary complications, such as a hypostatic pneumonia. If the patient has a chronic bronchitis, he should be allowed to sit up frequently upon a bed-rest and taught to take deep breaths. An effort should be made to treat such patients by one of the ambulatory methods.

1. *The Liston Splint Combined with Extension.*—The long external or Liston splint for an adult consists of a board four feet long, four inches wide, and one inch thick (Fig. 167). To the lower end a cross-piece (Fig. 167) is fastened by an iron brace and nails. The splint should reach from the axilla to six inches beyond the ankle. It is fixed to the body and leg by broad muslin bandages. Extension of the limb is obtained after shaving the limb by the use of broad strips of adhesive plaster as used

for fractures of the shaft of the femur (p. 245). The splint, carefully padded, is applied to the side of the trunk and injured limb. About fifteen pounds are used for extension.

The ends of the strips of adhesive plaster are rolled into a rope and tied through a pair of holes in the cross-piece of the splint. The foot should not touch the cross-piece. A well-padded perineal band is placed in position and the ends passed through a pair of holes in the upper part of the splint, so as to give good direction for traction with the perineal band. The method of applying the Buck's extension is described on p. 245.

The patient is anesthetized and traction is made by an assistant upon the cross-piece of the splint. When the limb is stretched to the same length as the normal leg, as shown by actual measurement, the perineal band is tied to the upper part of the splint. The advantage of this method is that extension is entirely within the splint, and the patient can be moved about and changed without disturbing the extension. At the end of six weeks the splint is removed and the patient allowed to get up with a body cast (Fig. 166).

The Ruth-Maxwell Method.—This method has been employed with great success by many surgeons since first advocated by Drs. Maxwell and Ruth.[47] Bony union was secured by Ruth in four cases, and good serviceable limbs in 100 per cent. of the cases. The thigh should be flexed at right angles to the trunk to relax the psoas and iliacus and bring their line of action above the neck of the femur to prevent them from in any way forcing soft tissues between the fragments; extension must now be made while an assistant makes traction outward on the upper end of the femoral shaft and raises the trochanter major to the same level as its fellow—fifteen to twenty-five pounds' weight is now to be used over a pulley to make downward extension on the leg; this is accomplished by the ordinary Buck's extension, with wide adhesive straps extending well above the knee and passing a cord through a pulley at the foot of the bed. The weight to be used must be proportionate to the muscularity of the individual, *i. e.*, sufficient to overcome the action of the long muscles, which act vertically. Binder's board or other material should now be molded to the internal, anterior, and posterior aspects of the upper parts of the injured thigh, and around this a broad band of muslin or other material is extended through a pulley at the side of the bed, about on a level with the highest point of the iliac crest, projecting a sufficient height above the bed and carrying sufficient weight to maintain the trochanter major as prominent as the one on the opposite side, and to overcome the posterior displacement of the weight of the thigh and the tendency to eversion.

The counterextension for longitudinal and lateral traction is made by the patient's weight. The foot of the bed is raised enough to overcome the tendency of the patient to slide toward the foot of the bed, and amounts to from ten to fifteen inches, according to the amount of weight required to overcome the muscular action. The side of the bed corresponding to the injured limb is also raised enough to overcome the tendency of the patient to be drawn toward the lateral pulley. The tilting required will be from two to five inches, and will depend somewhat on the width of the bed. A single narrow iron bed is to be preferred. Daily raising of these patients to the sitting posture, as above indicated, will not in the least disturb the fragments if the longitudinal and lateral traction are steadily maintained. Within one or two days these patients can usually raise the hips themselves with the sound leg so that the bed-pan can be readily used. Four to six weeks of confinement, which is all that is usually needed to procure union, is not an element of danger in itself; besides, no plan of treatment or non-treatment so far devised can give greater if equal comfort and freedom of movement.

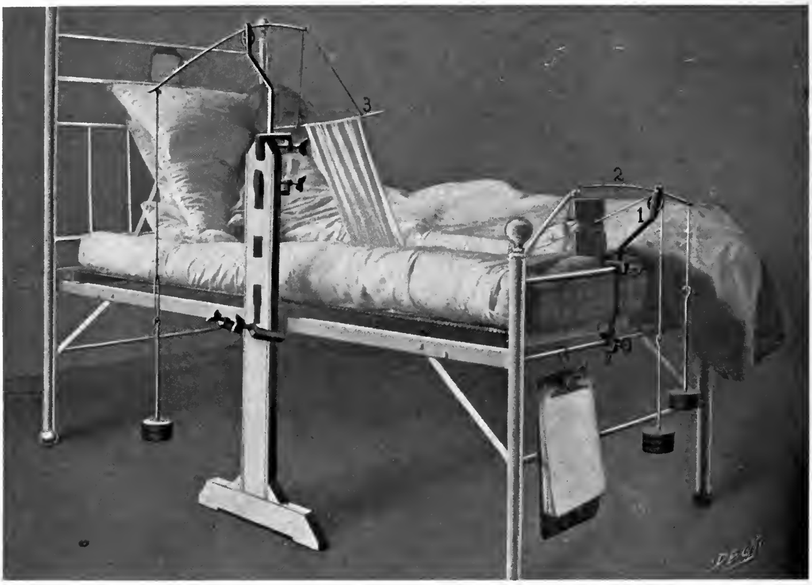


FIG. 168.—RUTH'S EXTENSION APPARATUS.
1, Buck's extension in the long axis of the limb; 2, lifting arrangement for relieving the pressure on the heel; 3, lateral extension and inward rotation apparatus (Fowler, after Ruth).

Thomas-Ridlon Splint (Fig. 169).—This is especially for patients who cannot be confined to bed whether the fracture is impacted or not. It gives excellent support to the fracture, and allows the patient to be lifted in bed or to be up and walking on crutches, the sole of the shoe of the other foot being raised. The exact description of its measurements, etc., is given in the article by Ridlon.[53] The splint is kept on for six to eight weeks, and the patient is then gradually allowed to get about upon crutches without the splint.

Hodgen Splint.—This splint is not so extensively employed at the present time as in former years, but deserves to be. It is a very convenient splint to use in elderly patients who are not strong enough to use an ambulatory method.

It consists of a rigid iron frame in the form of the letter U, the outer limb reaching from the anterior superior spine to three inches below the instep, the inner from the adductor longus tendon to the same spot, where the two limbs are united by a cross-bar three inches in width. The sides taper with the limb, and should be ¾ inch further apart than the diameter of the limb at any point. At the upper end the bars are united by an arch of the same material, which should correspond to Poupart's ligament; one or two similar arches are placed at equal points lower down. The splint is slightly bent at the knee.

Before applying the splint an ordinary extension apparatus is attached to the limb. Strips of flannel about seven inches wide are then cut and arranged beneath the limb at right angles to its direction, each one overlapping the next; the length of the strips should be rather more than the circumference of the limb at the spot to which each is to be applied. The splint is then placed in position; the strips of flannel are raised in succession, and, being lapped over the bar, are pinned or stitched there, so that the limb lies in a flannel trough. The cord of the extension appliance is then securely tied to the lower end of the splint. Two hooks are soldered to each side of the frame, and to them are attached cords, which are brought together over the limb; another stout cord is tied to these and passes over a pulley attached to a vertical post at the end of the bed, where it is weighted to a sufficient extent. The limb when the weight is applied should lie free of the bed, even to its extreme upper limit. When correctly applied, the splint itself is pulled on by the extending force (the weight), and this is transmitted to the limb through the stirrup end, which should be taut, "like a harp-string"; laxity of this end indicates slipping of the splint and necessitates its readjustment.

Fig. 169.—Posterior View of Ambulatory Splint in Treatment of Fracture of the Femur (Davison).

Treatment in Cast with Limb Abducted.—Royal Whitman has recently[54] recommended the treatment of fractures of the neck of the femur in adults, as well as in early life, by placing the leg in an abducted position which shall be as near the normal abduction of 45 degrees as possible. A body cast is applied, while an assistant slowly and under gentle traction abducts the injured limb, the surgeon meanwhile supporting the joint with his hands and pressing gently downward upon the trochanter. When the normal limit has been reached, a long plaster cast is applied. The cast is strengthened beneath the joint by a bar of steel or aluminum shaped like the Thomas hip-splint.

The particular advantages of this attitude are:

1. When the extended limb is placed in complete abduction, the trochanter is firmly apposed to the side of the pelvis, so that upward displacement of the femur is impossible.

2. In this attitude the capsule is made tense; thus it should serve to direct fragments toward one another.

3. The deforming influence of muscular contraction is removed,

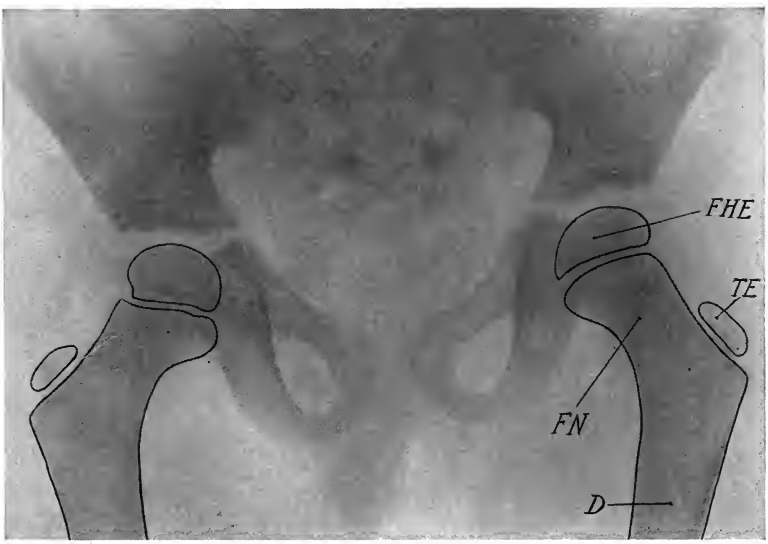


Fig. 170.—Skiagraph of Normal Hip-joint of Boy of Ten.
Showing relation of head of femur to neck. FHE, Upper epiphysis forming the head of the femur; TE, trochanteric epiphysis; FN, neck of femur; D, shaft.

since the abductor group is relaxed, while the contraction of the iliopsoas muscle in this position would draw the fragments toward one another.

The patient, having been anesthetized, is placed in the position already described. The limb on the injured side is flexed somewhat and rotated inward to disengage folds of capsule that may have fallen between the fragments. Manual traction with countertraction is then made until the limbs are shown by measurement to be of equal length. The assistant then abducts the extended limb on the pelvis, which is fixed by full abduction of its fellow, the operator supporting the joint and pressing the thigh upward from beneath, the aim being to force the fragments forward against the tense anterior wall of the capsule.

Whitman has employed this method in a number of cases in children and young adults, but its use in adults has been limited to three cases.

The result in only one case, that of Ashcroft,[55] is mentioned. There was perfect functional recovery.

The use of this method in children is referred to on p. 239.

Operative Methods.—In cases of non-union several methods of operative interference have been employed. These are: (*a*) The removal of the head of the bone in old ununited fractures; (*b*) fixation of the fragments by wire, steel nails, ivory pegs, screws, etc. A number of cases of the first-named method have been reported, resulting in great improvement in the use of the limb after removal of the head. Fixation of fragments by various mechanic devices can be considered in recent and old cases. The incision usually employed is one extending three to four inches downward from the anterior superior spine along the outer border of the sartorius. The cases which seem best adapted for operation are those in which the fracture is at the narrow portion of the neck. Freeman[56] has collected 12 cases with good functional results. Nicolaysen[57] has reported 21 cases in which he nailed the fragments in recent fractures. Fritz König[58] is a warm advocate of operative interference in fractures at the narrow part of the neck. He advises operation at the end of eight days. The entire subject of the operative treatment of recent and old ununited fractures is still an unsettled question. If nails, ivory pegs, or screws are used, they are driven through the trochanter into the head and a body cast applied (Fig. 74).

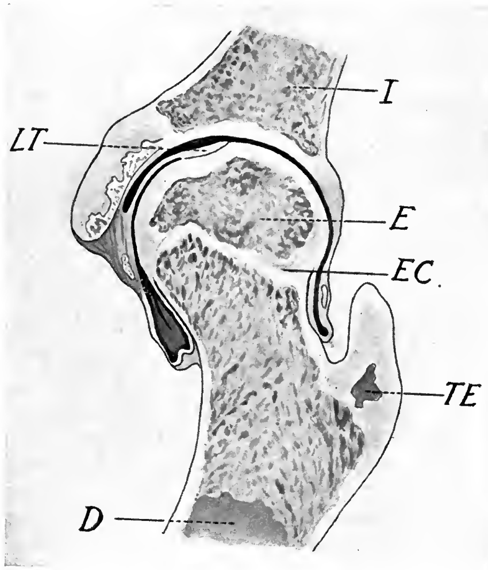


FIG. 171.—FRONTAL SECTION OF HIP-JOINT IN A BOY OF EIGHT.

I, Ilium; LT, ligamentum teres; E, upper epiphysis forming head of bone; EC, epiphyseal cartilage; TE, trochanteric epiphysis; D, shaft of femur (after von Bruns).

Injuries of the Neck of the Femur in Early Life.—It was formerly believed that fractures of the neck of the femur and epiphyseal separations of the head of the bone were extremely rare injuries. In recent years a number of articles by Hoffa, Hofmeister, Hesse, Whitman, and others have appeared which show that in the majority of cases a diagnosis was not made at the time of the injury. The patients were often seen on account of a traumatic coxa vara which was the direct result of the injury at the neck of the femur. The name coxa vara traumatica was first given by Sprengel[59] in 1898 to a condition following injuries of the neck of the femur in childhood and adolescence. According to Sprengel, Hoffa, and others the resultant deformity, which consists of a bending downward of the neck of the femur (Fig. 172), is due to an epiphyseal separation which may be complete or incomplete. Whitman[60] is of the opinion that the traumatic coxa vara is due to a true fracture of the neck of the femur in the majority of cases, and that epiphyseal separation is comparatively rare. Traumatic coxa vara may follow even a slight injury. Whitman[54] has seen 36 cases of fracture of the neck in childhood and early youth in sixteen years, and Hesse[55] has recently tabulated 42 others. Hoffa and many other German surgeons believe that fracture of the neck is rare in children, while epi-

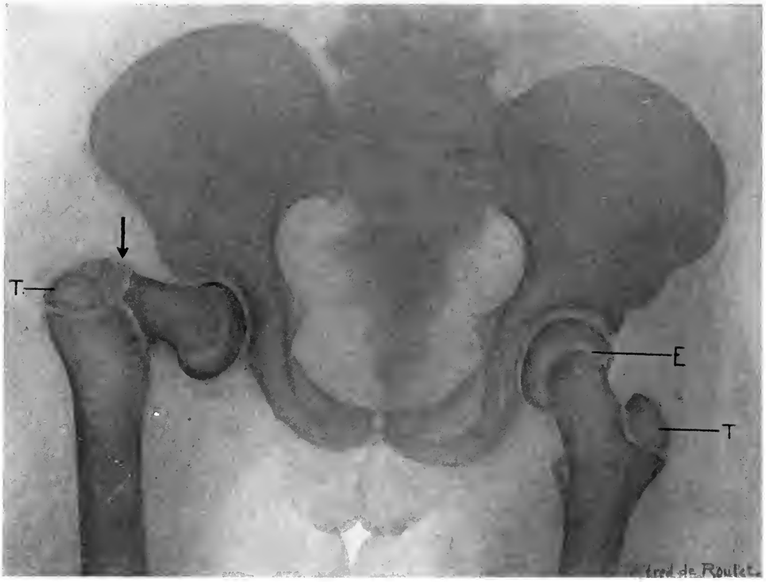


FIG. 172.—SKIAGRAPH OF CASE OF COXA VARA FOLLOWING FRACTURE OF NECK OF FEMUR CLOSE TO SHAFT IN EIGHT-YEAR-OLD CHILD.
The arrow points to the line of fracture. T, Trochanteric epiphysis; E, epiphysis forming head of normal side; T, trochanteric epiphysis on normal side (H. A. Wilson).

physeal separation is common. Whitman holds opposite views and divides fractures of the neck in early life into two classes:

(*a*) Simple direct fracture of the neck, usually incomplete, occasionally complete; (*b*) direct epiphyseal separation, usually incomplete, rarely complete.

The **diagnosis** of these cases is seldom made at the time of the injury. The two forms can, however, be differentiated clinically and by the *x*-ray. In fracture of the neck there is more shortening, less outward rotation, and the trochanter is more prominent. Motion at the hip-joint is practically free, except in abduction, which is particularly restricted when the limb is flexed. In epiphyseal separation the shortening is less, the outward rotation greater. Frequently there is a swelling to be felt over Scarpa's triangle over the position of the head, the trochanter is not as prominent, and motion at the hip-joint is always more restricted. The cases are often seen months to years after the accident, when disability due to the resultant coxa vara is the most prominent symptom.

The diagnosis of this condition can be made from the x-ray (Fig. 172) as well as from the presence of shortening of the limb, outward rotation, and elevation of the trochanter. The treatment at the time of injury is best carried out by the use of the abduction method, as advocated by Whitman and described on p. 235. This method is useful for both varieties of injuries at the neck, but especially for those at the base. The only appliance of equal efficiency is the Thomas hip-splint. If there is marked displacement of the head, operation is indicated to reduce it. Instead of the body cast with the limb in abduction, the ordinary extension method can be employed. After healing is complete a supporting hip-splint should be worn for a year at least.

Fractures of the Acetabulum.—These were formerly thought to occur either very seldom, or only as a complication of a backward dislocation of the pelvis. Graessner[61] has called attention to the fact that they occur as isolated fractures far more frequently than was considered possible before the use of the x-ray. One variety which is rare is that in which, after a fall or similar force acting upon the trochanter, the head of the bone penetrates the acetabulum, splitting it into three or more parts. The head then enters the pelvis. This form of fracture is spoken of as a central dislocation of the hip, and is referred to on p. 421 (Fig. 302). Katz has collected 11 cases of this injury. The more frequent form of fracture of the acetabulum is one involving its posterior rim. Many of such cases are treated as contusions of the hip or incomplete dislocations of the head of the femur. The diagnosis may be made from the following symptoms: pain follows pressure over the trochanter and also when the limb, while extended, is pressed against the pelvis.

The flattening of the trochanter is more marked than in an impacted fracture of the neck of the femur. There is little or no shortening and no eversion of the limb. There is tenderness over the acetabulum on rectal examination. If the fragments have been pushed inward by the head, as in the central variety, a bulging can be felt through the rectum. Crepitus is absent. The x-ray (Fig. 173) is the most reliable means of diagnosis.

The most satisfactory method of treatment is combined longitudinal and lateral traction (Fig. 168).

Fractures of and Through the Greater Trochanter.—Both of these are very rare forms of fracture. Neck[62] has reported a typical case of isolated tearing off of the greater trochanter following forcible external rotation while the limb was fixed. The fragment was palpable and movable. The diagnosis in such cases can be made only from the presence of pain localized over the greater trochanter and by the x-ray. In fractures through the greater trochanter (the pertrochanteric fracture of Kocher) one cannot make a differentiation from an ordinary fracture of the neck unless a prominent angle formed by the two fragments is distinctly visible anteriorly. The eversion and shortening are the same as in a fracture of the neck.

Isolated Fracture of the Lesser Trochanter.—This is also a rare

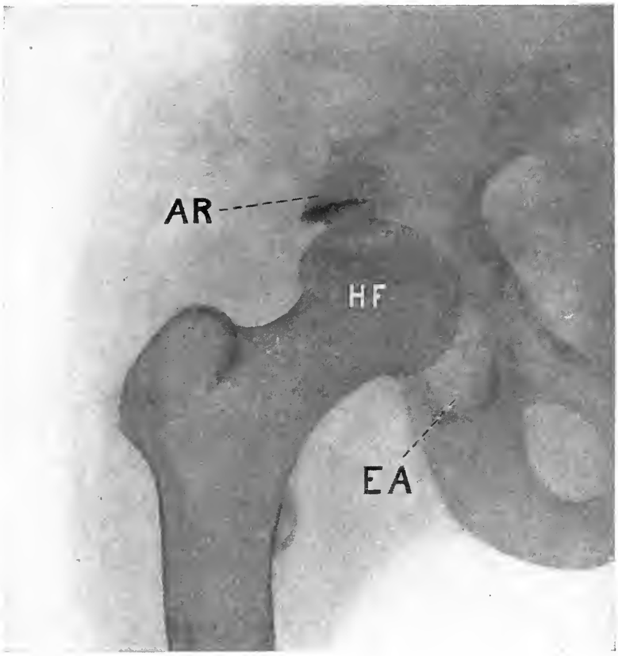


Fig. 173.—x-Ray of Fracture of Rim of Acetabulum.

AR, Fragment of rim of acetabulum, which has been displaced upward and backward; H F, head of femur which has been allowed to be displaced through the absence of the acetabular rim, thus causing a backward and upward dislocation of the hip-joint.

form of fracture, the knowledge of which is increasing with the use of the *x*-ray. Juillard has reported such a case in which the diagnosis of fractures of the neck had been made.

FRACTURES OF THE SHAFT OF THE FEMUR.

These are best divided into those—(*a*) of the upper (subtrochanter); (*b*) of the middle, and (*c*) of the lower third (supracondyloid) of the shaft. They occur most frequently between the ages of twenty and sixty, especially in working people. The causes are direct and indirect violence and muscular action.

Direct violence is most apt to cause a fracture of the lower third, and may follow such an accident as being crushed between two objects or being run over or a heavy blow upon the bone.

Fracture by indirect violence is most apt to follow a fall upon the feet. The resulting fracture may, under these circumstances, be either due to a bending of the bone, causing an oblique or transverse fracture, or the force may act in a twisting manner, giving rise to spiral fracture.

x-Ray studies[63] have shown that the spiral form of fracture occurs quite often in the femur. In children it is situated in the middle third, in very old people at the junction of the upper and middle thirds, and in younger adults between the middle and lower thirds. The fracture is usually the result of a fall upon the feet with torsion of the body,[64] or the latter alone may produce it while standing. These spiral fractures are most difficult to treat and are referred to again on p. 262.

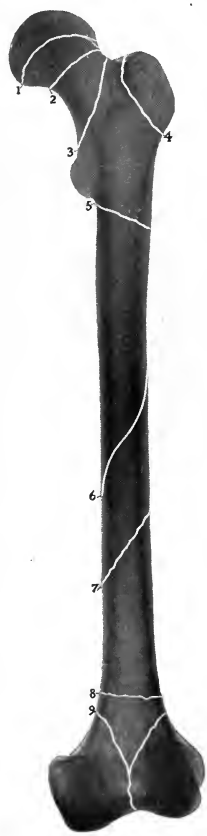


Fig. 174.—Location of Most Frequent Fractures of Femur.

1, Epiphyseal separation, at upper end; 2, subcapitalis, that is, at junction of head and neck; 3, junction of neck and shaft (extracapsular); 4, of greater trochanter; 5, subtrochanteric of shaft; 6, spiral of shaft; 7, oblique of shaft; this may occur at any portion of shaft; 8, supracondyloid; 9, T or Y shaped at lower end.

Fractures of the shaft may be complete or incomplete. Incomplete fractures are rare, but occur both in adults and children, the line of fracture being transverse. Fissures also occur, but infrequently. Complete fractures of the shaft may be multiple or comminuted, and those of the middle third are often compound, the fragment penetrating the skin as in the case shown in Fig. 175. Injuries of vessels and nerves, although infrequent, must be constantly thought of, especially in supracondyloid fracture. In the latter variety the lower fragment is pulled backward by the gastrocnemius muscle and may penetrate or impinge upon the popliteal vessels (Fig. 176) and cause gangrene of the leg.

In fracture of the upper third the line of fracture is usually oblique, the upper fragment being displaced upward and forward, the lower one upward and inward, resulting in a greater degree of shortening than is present in fractures of the other two-thirds of the shaft.

In fractures of the middle third, the line of fracture is either oblique or spiral. Even in healthy children the periosteum often remains untorn in fractures at this level. Both fragments are usually displaced outward, forming an angle, or there is considerable overlapping of the fragments.

In fractures of the lower third the line of fracture is often transverse and the upper fragment overrides the lower, the latter being tilted backward (Fig. 176).

Diagnosis.—The diagnosis of these fractures usually presents no difficulties. Their recognition is easier when the fracture is complete and the periosteum has been torn. In such patients the usual signs of fracture, viz., abnormal mobility, deformity, crepitus, loss of function, and pain are quite marked.

If the fracture is incomplete or the periosteum has not been torn, as not infrequently occurs in children, especially in those suffering from scurvy or rachitis, the diagnosis is far more difficult. This is due to the fact that there is but little deformity and the diagnosis depends chiefly upon the elicitation of crepitus and abnormal mobility, combined with localized pain and loss of function.

The diagnosis of fractures of the shaft depends to a great extent upon the recognition of the deformity and shortening which result from the displacement of fragments. This is often so marked and visible as to require but little manipulation.

The degree of shortening can be determined by measurement of the limbs from the anterior-superior spine of the ilium to the lower border of the inner malleolus, and comparing it with that of the opposite limb.

Fig. 175.—Method of Examination for Fracture of Shaft of Femur.

The injured thigh is laid upon the outstretched hand of the examiner, with palm upward, while the opposite hand grasps the middle of the leg. While the hand which is supporting the point of fracture fixes the thigh to some extent, the opposite hand, by a motion to and away from the median line of the body, enables one to determine the false point of motion. In this illustration the forward bowing of the limb due to slipping of the fragments past each other is well shown, causing considerable shortening of the limb.

Both limbs should form the same angle with the pelvis when the measurements are made, and should be brought as close to the median line of the body as possible.

Abnormal mobility and crepitus are most marked in fractures of the upper and middle thirds, especially if complete, and can be best elicited by grasping the limb in the manner shown in Fig. 175.

The projecting ends of the upper and lower fragments can often be felt beneath the skin in simple, or they project through it in compound, fractures. In fractures of the lower third the diagnosis is more difficult, on account of the accompanying effusion into the knee-joint and the slighter degree of displacement of fragments. There are usually, however, marked loss of function, swelling, and some degree of deformity.

In every case in which the diagnosis of fracture of the lower third of the femur (supracondyloid) has been made an examination of the limb distal to the knee should be made. This should include—(*a*) the palpation of the superficial arteries, like the dorsalis pedis and posterior

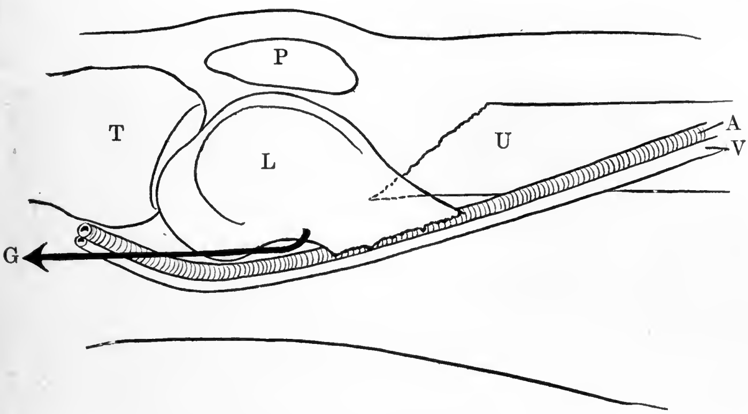


FIG. 176.—SUPRACONDYLOID FRACTURE OF FEMUR.

The illustration shows how the gastrocnemius muscle, whose action is represented by the black arrow, terminating at the letter G, causes the lower fragment to be pulled downward and backward, impinging upon the popliteal artery and vein, and resulting in gangrene of the leg in some instances.

tibial, for loss of pulsation as the result of injury of the popliteal artery, and (*b*) the changes in color of the limb, swelling, etc., which might result from compression and thrombosis of the popliteal vein (Fig. 176).

Treatment.—The method of treatment to be adopted in a given

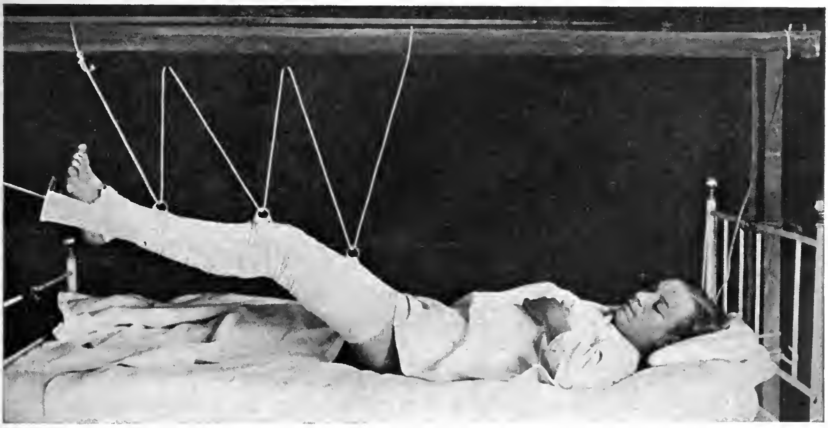


FIG. 177.—METHOD OF SUSPENSION BY ANTERIOR MOLDED SPLINT IN TREATMENT OF FRACTURES OF THE FEMUR (Davison).

case depends, first, upon the location of the fracture; second, upon the direction of the line of fracture, whether oblique or spiral, and the resulting amount of displacement. Compound fractures of the shaft require no special mention (p. 131). The best method of emergency treatment is to use two boards as side splints. One is placed on the outer and the other on the inner side of the limb. The outer one should extend from the axilla to below the toes, the inner from the groin to the foot. These should be well padded and held together by wide bandages, traction being made upon the foot while this is done.

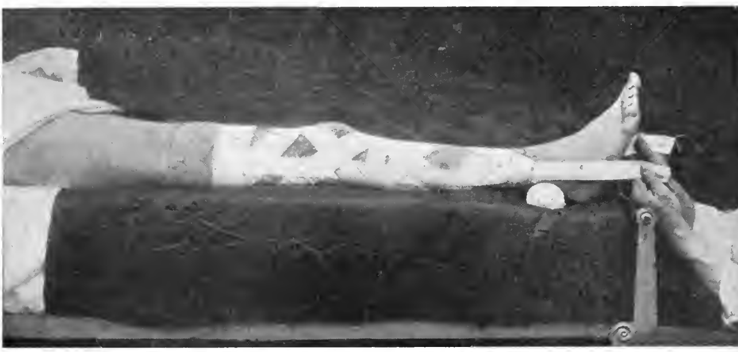


Fig. 178.—Adhesive-plaster Extension Strips for Fracture of the Thigh. Long, upright, circular, and obliquely applied strips (Scudder).

The first step in the treatment proper is to give an anesthetic and reduce the fracture by traction upon the leg.

In subtrochanteric fractures the upper fragment is pulled upward and rotated outward by the action of the iliopsoas muscle and the rotators of the hip. The usual methods of treatment by long splints and extension always give union with angular deformity and faulty rotation.

Fig. 179.—Fracture of the Thigh.
Completed apparatus, and, in addition, a long outside T-splint, straps, and swathe. Weights applied (Scudder).

The indication for treatment is to place the long lower fragment in such a position that its axis will be in line with that of the upper fragment and with the same amount of external rotation.

This can be accomplished by suspension of the leg in the proper position in a frame by the Beely anterior molded plaster splint and Buck's extension (Fig. 177).

A Buck's extension is put on the leg, the knee is slightly flexed, and a splint is molded to the anterior part of the leg and thigh, with wicking soaked in plaster cream and secured with a roller bandage. A series of rings are incorporated into the splint for suspension of the limb. The rings should be in such a position as to get the necessary rotation of the lower fragment to match the faulty rotation of the small upper fragment when the leg is suspended. The leg is suspended sufficiently high to equal the flexion of the small upper fragment. The frame is attached to the outer part of the foot of the bed in such a position that the lower fragment will be in the axis of abduction of the small upper fragment (Fig. 179). Sufficient weight on the Buck's extension will overcome the shortening. When the immobilization is complete, the reduction of the fracture should be verified by the fluoroscope.

Fracture of the shaft in adults that can be reduced by direct extension

FIG. 180.—SUSPENSION METHOD OF TREATMENT OF FRACTURES OF THIGH IN CHILDREN (Davison).

may be treated by the Liston splint (p. 232). A small posterior splint can be added to prevent sagging of the fragments. Buck's extension is applied to the leg in the following manner:

The limb from the toes to the groin is scrubbed with green soap and water. If any hair is present, the entire limb is shaved. The foot is covered with a flannel bandage from the toes to just above the malleoli. An assistant now makes traction upon the foot. Two long strips of zinc oxid adhesive plaster, each two inches wide, are cut. They should be long enough to extend from the middle of the thigh to a point six inches beyond the sole of the foot. The inner sides of these two strips are covered either with muslin or other strips of adhesive plaster from just above the ankle to just beyond the foot, in order to prevent the long extension strips from adhering to the bandage which has been placed around the foot and ankle. The long strips are now applied to the sides of the thigh and leg (Fig. 178) and secured in place by broad circular strips around the limb just above and below the knee and at the middle and lower thirds of the leg. The ends of the long lateral strips are attached to a spreader or foot-piece. The latter is a piece of wood, half an inch thick, two inches wide, and a little longer than the width

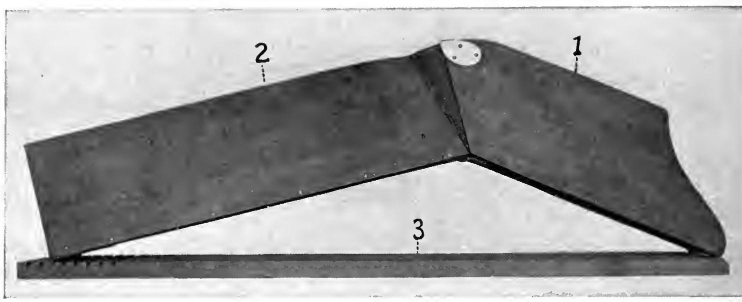


FIG. 181.—DOUBLE-INCLINED PLANE SPLINT FOR USE IN TREATMENT OF FRACTURES OF LOWER THIRD OF FEMUR. (See Fig. 184.)
Through a series of notches in the base-board and hinges at the junction of the thigh and leg portion the angle can be changed at will.

of the foot. A hole is drilled through its center to permit the extension cord to pass through. This cord should be about three feet long and the size of a clothes-line. It is passed though the opening in the spreader and tied in a knot so that it will pull upon the spreader or foot-piece.

Extension is now made across a pulley fastened to the end of the bed (Fig. 179). About five bricks, each sewed in a canvas bag, should

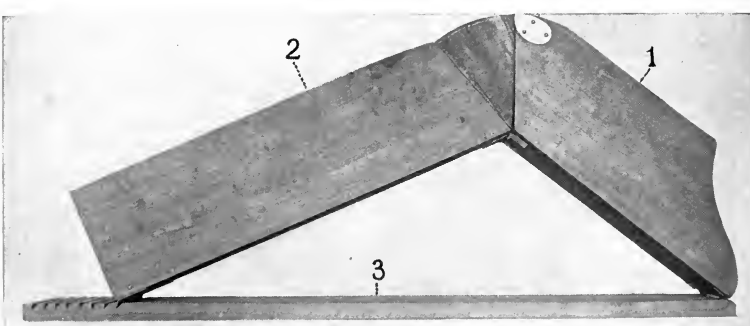


FIG. 182.—DOUBLE-INCLINED PLANE SPLINT FOR USE IN FRACTURES OF THE LOWER THIRD OF THE FEMUR.
1, Thigh portion; 2, leg portion; 3, base-board, on which the splint rests. The angle can be changed at will, as can be seen by comparison with Fig. 181.

be attached to the end of the cord (Fig. 185). This corresponds to a weight of twenty-five pounds and suffices for extension in the average adult. The foot of the bed is elevated about six inches by bricks or blocks of wood, with a depression cut out of their upper surfaces to prevent the feet of the bed from slipping. If there is any tendency to displacement in fractures of the shaft of the femur, after the extension has been applied short splints can be used opposite the point of fracture.

Fractures of the shaft in adults can also be treated by a plaster-of-Paris body cast while extension is made upon a piece of iron which is placed externally and incorporated into the cast. Its lower end is bent at right angles. This method of treatment permits the patient to get up and walk around on crutches, the sole of the opposite foot being raised. Instead of this the long Taylor hip traction splint can be used.

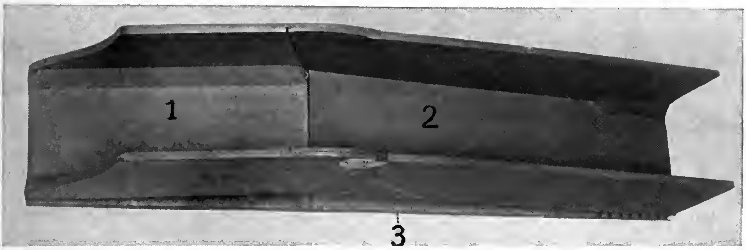


FIG. 183.—VIEW FROM ABOVE OF DOUBLE-INCLINED PLANE SPLINT FOR TREATMENT OF FRACTURES OF THE LOWER THIRD OF FEMUR.
1, Thigh portion; 2, leg portion; 3, base-board.

In children a fracture of the shaft is most easily treated by the use of Schede's vertical suspension (Fig. 180). Sufficient weight should be applied barely to lift the nates, so that a bed-pan can be easily used without disturbing the fragments. Supracondyloid fractures are best treated by the double-inclined plane (Fig. 184).

The small lower fragment is flexed with Buck's extension upon the leg by the action of the gastrocnemius muscle.

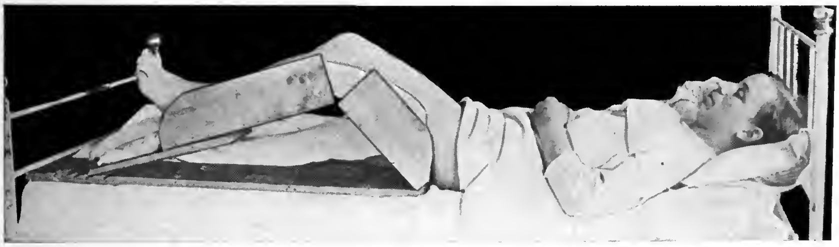


FIG. 184.—USE OF DOUBLE-INCLINED PLANE SPLINT IN TREATMENT OF FRACTURES OF THE FEMUR (Davison).

To reduce the fracture the leg must be flexed upon the thigh until the lower fragment takes the same axis as the upper fragment. The limb should be placed, well padded, in the double-inclined plane, and the angle of the splint changed until the fragments are in the same line. The weight of the body pulling against the fixed flexed knee will produce sufficient extension.

In spiral fractures of the shaft (usually the middle) the best method of treatment is by extension combined with the Liston splint. Reduction of the fragments is much more difficult than in the majority of fractures.

After-treatment and Prognosis of Fractures of the Shaft.—Bony union occurs in children in four to six weeks and in adults in six to eight weeks. Delayed union is not infrequent, and usually requires a longer time and more perfect immobilization. In elderly people there is great danger of bedsores and of hypostatic pneumonia. This can be guarded against by treating the fracture by some ambulatory method or in the manner described on p. 234.

At the end of the sixth to eighth week all apparatus should be removed and the patient allowed to lie in bed for one week without any splints. The limb should be massaged daily, and active and passive motions of the knee and hip begun. The patient is allowed to get up daily for a short time upon crutches and gradually allowed to bear his weight upon the injured limb. The most frequent causes of disability are due to—(*a*) angular deformity causing a sharp or gradual outward bowing of the limb, with resultant shortening of the limb, and (*c*) rotation of the limb inward or outward. Other factors in producing a bad result are stiffness or bowing backward of the knees. The majority of these can be avoided by daily attention to the details of the treatment. A useful limb often results in spite of moderate overriding and lateral deformity, but angular and rotary displacements interfere greatly with the usefulness of the limb. A good result has been obtained if not more than one inch of shortening exists and there is no angular or rotary deformity.

FRACTURES OF THE LOWER END OF THE FEMUR.

These resemble those of the lower end of the humerus. They are: (*a*) Intercondyloid; (*b*) fractures of either condyle; and (*c*) separation of the lower epiphysis.

In the intercondyloid variety the line of fracture is either T or Y shaped. The fracture is very apt to be compound and associated with injury of the popliteal vessels. The diagnosis is made from the independent mobility of the two condyles on each other, when they are moved backward and forward, and by the pain when they are pressed together. Effusion into the knee-joint is constant and often obscures the recognition of the fracture.

Separation of either condyle is not accompanied by any shortening. It is quite rare and is usually overlooked, because there is but little displacement.

Separation of the lower epiphysis of the femur is next in order of frequency to epiphyseal separation of the upper end of the humerus. The epiphysis is usually displaced forward and the shaft pulled backward by the gastrocnemius muscle. The latter displacement may in many cases endanger the popliteal vessels, as in supracondyloid fracture (Fig. 176).

The epiphysis may also be rotated 90 degrees, so that its joint surface faces the patella. The diagnosis can be made from—(*a*) the presence of abnormal mobility in a young person, just above the knee-joint; (*b*) the palpation of the two fragments, the lower in front of the upper; (*c*) the elicitation of a soft, cartilaginous crepitus, and (*d*) by an *x*-ray picture which should be made in every case before and after reduction. One should never neglect to search for absence of pulsation of the superficial arteries below the point of fracture and note any changes in color of the limb.

Treatment.—The chief objects to be accomplished are: to reduce the fragments accurately and prevent ankylosis of the knee. In fracture of either condyle and in the intercondyloid variety the best position in which to keep the knee is in extension. Massage of the knee-joint should be begun early, say at the end of ten days, and passive motion at the end of the fourth week. In separation of the lower epiphysis every effort should be made to reduce the fragments without incision. If the lower fragment is displaced forward, the best method of reduction is that shown in Fig. 187, as suggested by Reisman.[65] The knee being strongly flexed, traction is made for-

Fig. 185.—Method of Securing Extension in Fractures of the Lower Third of the Femur by Use of Double-inclined Plane Splint.

About fifteen to twenty pounds extension are used, each brick weighing approximately five pounds, and is inclosed in a bag made of ticking.

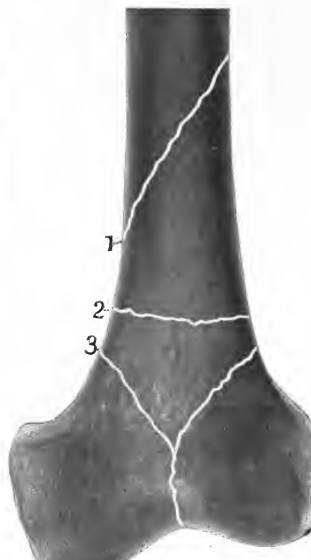


Fig. 186.—Location of Fractures at Lower End of Femur.

1, Oblique at lower third of shaft; 2, supracondyloid. 3, T or Y-shaped at lower end.

ward upon the calf, while traction from below upward is being made upon the thigh (Fig. 187). If the deformity has been reduced, the shortening of the leg will disappear. If non-operative measures fail, it is advisable to make an incision over the outer side of the knee and reduce the fragments. It may be necessary to suture them to keep

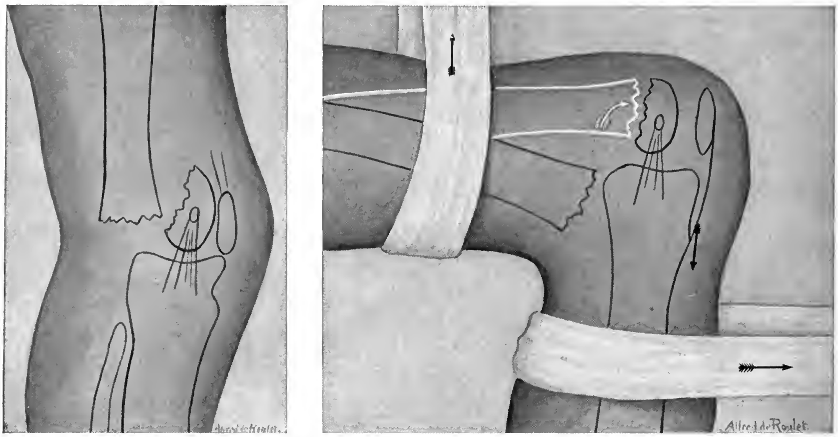


FIG. 187.—MOST FREQUENT VARIETY OF DISPLACEMENT IN SEPARATION OF THE LOWER EPIPHYSIS OF THE FEMUR, AND PROPER METHOD OF NON-OPERATIVE REDUCTION.

Traction is made in upward direction by means of a loop of muslin passed around the thigh, traction in a forward or anterior direction being made through a similar loop passed around the middle of the calf, closer to the knee-joint (Reisman).

them in position. A light plaster cast with the knee flexed should be applied. It should be removed after six weeks and massage and light passive motions be begun. Summa[66] has reported one successful operative reduction of his own and has collected three others.

INJURIES IN THE VICINITY OF THE KNEE-JOINT.

These include:

1. Fracture and epiphyseal separation at the lower end of the femur (p. 248).
2. (*a*) Fracture or (*b*) dislocation of the patella.
3. Dislocation of the knee (upper end of the tibia).
4. Fracture of the upper end of the (*a*) tibia and (*b*) fibula.
5. Sprain or other injuries of the knee-joint proper and its ligaments.

In every case of injury in the vicinity of the knee one must determine which of the above-named injuries exists by a systematic examination as follows:

(*a*) *Inspection.*—This will often show at once the presence of a deformity or swelling of the knee-joint proper, with obliteration of its normal depressions on either side of the patella, and changes in color of the limb due to injury to the vessel.

(*b*) *Palpation and Manipulation.*—This will show: (1) whether there is fluid in the knee-joint by ballottement of the patella and measurement of the circumference. (2) Palpation of the surface and position of patella will show the presence or absence of a fracture or dislocation of this bone. (3) Manipulation of the knee, as shown in Fig. 188, will reveal the presence of abnormal mobility due to laceration of the lateral ligaments. (4) Palpation and manipulation of the lower end of the femur and upper end of the bones of the leg will reveal the presence or absence of abnormal relation to each other, as in dislocation of the knee or of abnormal mobility, deformity, or crepitus, as in fractures or epiphyseal separation. (The methods of examination for ruptured ligamentum patellæ and for injuries of the semilunar cartilages are given elsewhere.)

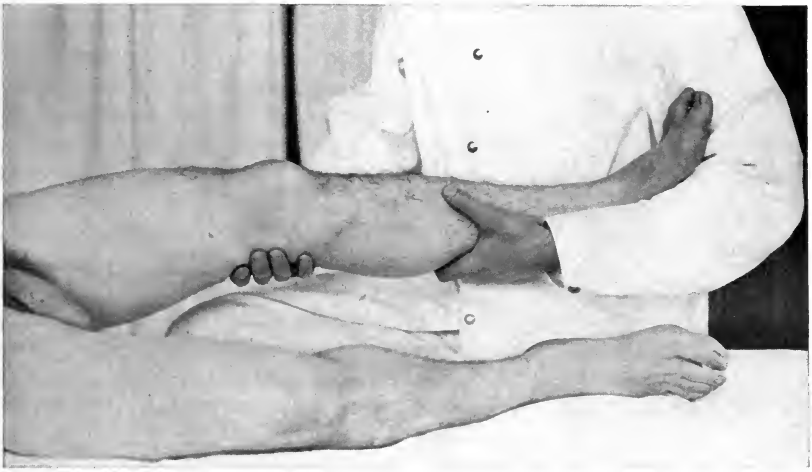


Fig. 188.—Method of Determining Abnormal Lateral Mobility of Knee-joint, Due to Tearing or Stretching of the Lateral Ligaments.

The patient, while lying down, is grasped so that the knee rests upon the palm of the examiner's right hand, if the left limb is to be examined, and vice versâ in the case of the right limb, while the opposite hand grasps the leg at about its middle, the object being to fix the knee more or less with the hand beneath it, while the other hand, by to-and-fro motions, determines any increase in lateral mobility.

Fractures of the Patella.—The patella may be regarded as a sesamoid bone inserted into the strong aponeurotic terminations of the extensor muscles of the thigh. Fractures of the patella occur most frequently between the ages of thirty and fifty. They are very rare in children. It was formerly believed that these fractures were either the result of direct violence or of muscular contraction. Recent studies by Bahr[68] and others have shown two important facts in regard to their etiology and mechanism. The first of these is that the majority (nearly 80 per cent.) of all fractures of the patella are the result of a direct violence, such as a fall or a blow upon the knee. In these the line of fracture is either stellate, transverse, oblique, or longitudinal. The second important fact is that fractures which were supposed to be due to muscular contraction of the quadriceps alone are comparatively rare, and can occur only when the knee is extended. In the majority of cases formerly believed to be due to muscular contraction alone, the fracture is the result of a combination of a muscular contraction and of indirect violence. When a person tries to save himself from slipping or falling by a sudden contraction of the quadriceps, the knee is flexed. The patella is fixed below by the ligamentum patellæ, and above by the contracted quadriceps. The only portion of the patella which remains in contact with the lower end of the femur is the middle, and this is snapped across the underlying femur as one would break a stick across the knee. Thus the fracture is usually transverse and a little below the middle. The line of fracture may be oblique or longitudinal in these fractures by indirect violence. It was formerly thought that a longitudinal fracture could be due only to such a direct violence as falling upon

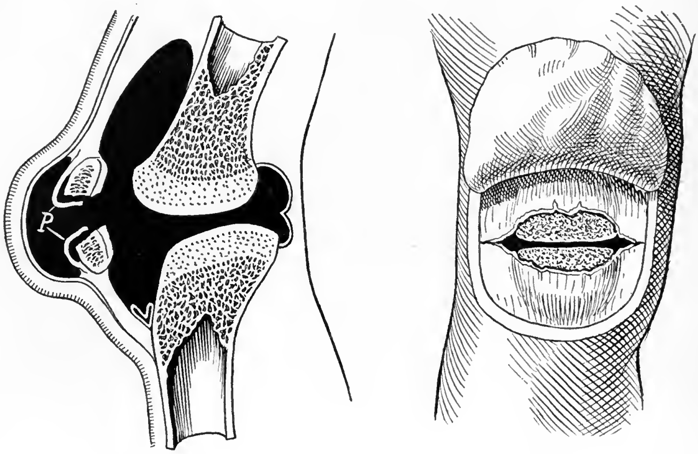


Fig. 189.—Two Views of Anatomic Conditions in Fractures of the Patella.

A, Effusion, usually of hemorrhagic character, in the prepatellar bursa and in the knee-joint itself. Note how the periosteum of the patella (*P*) is inverted. *B*, Front view of fractured patella. Note the tears in the aponeurosis, lateral to line of fracture, a frequent complication of this variety of fracture.

a sharp stone or the edge of the curb. A number of cases have, however, been reported by Hoffa and Meyer,[69] showing that a longitudinal fracture as the result of indirect violence is not infrequent.

Fractures of the patella may be complete or incomplete. A few cases have been reported of multiple transverse fractures. Displacement is rarely found in longitudinal or oblique fractures, but is almost invariable in the transverse or stellate variety. The diastasis or separation of fragments in the transverse variety varies from a distance sufficient to allow the finger to be placed between the edges, to a diastasis of three and one-half inches. It is of considerable importance from the standpoint of treatment to know four conditions which accompany a fracture of the patella, especially the transverse variety. These conditions are:

(*a*) A tear of the lateral portions of the aponeurosis.

(*b*) A folding in of the periosteum (Fig. 189) over the edges of the fracture.

(*c*) More or less hemorrhage into the knee-joint.

(*d*) A tilting of the lower fragment forward, less often a tilting of the lower fragment backward.

Hemorrhage into the knee keeps the fragments apart until it is absorbed, and the folding in of the periosteum over the edges prevents accurate approximation. This latter essential to good union is also interfered with by the diastasis and tilting of the fragments. The rôle which the accompanying tear in the aponeurosis plays has come to be regarded as of the utmost importance.

A rupture of the quadriceps tendon or of the ligamentum patellæ is as serious an injury, so far as the possible loss of power of extension of the knee is concerned, as a fracture of the patella itself. Schmidt[70] has shown that if the patella has been removed or does not act on account of a wide separation of fragments, its function of assisting in extension of the knee is vicariously assumed by the fibers of the fascia lata, which are subject to muscular control, as well as the lateral expansions of the rectus, vasti, and sartorius. This will be referred to again under treatment. The degree of the tear in the lateral aponeurosis is, therefore, not only of importance on account of its causing separation of the fragments, but also on account of its interfering with the power of extension.

Fortunately, as a rule, the tear does not involve the so-called reserve portions of the aponeurosis, *i. e.*, the extreme lateral parts, which were referred to above as assuming the function of extension vicariously. In refractures the lateral tears are usually larger than in the original injury.

The recognition of the extent of the lateral aponeurotic tear will be referred to again under diagnosis. Whether bony union ever occurs after a fracture of the patella is still an unsettled question. Thiem,[71] who has made a study of this subject, says there are no instances of a bony union. Hoffa and others claim that bony union is possible. In the majority of cases the union is a close fibrous one, bony union being prevented by the interposition of the periosteum. All published results of recent years show that close union of fragments does not always mean a good functional result. The latter is more directly dependent upon the aponeurotic tears and the degree of atrophy of the muscles of the thigh, which invariably accompanies a fracture of the patella.

Diagnosis.—The signs of this fracture are loss of power of extension of the limb, swelling of the knee-joint, a palpable separation of the fragments, and pain in the knee. The patient is unable to raise the injured limb from the ground while either lying down or standing up. It has been proposed by Ransohoff[72] and others to test the extent of the tear in the lateral portions of the aponeurosis, and that this should serve as an indication for operative interference. That such a test is apt to lead to wrong conclusions if tried within the first few days after the accident is self-evident. If there is much contusion of the soft parts or a considerable amount of effusion into the knee-joint, these alone would prevent voluntary extension.

If such a test is employed, it is of value only when most of the swelling has disappeared, and this is the most favorable time to operate, so that the test is best made at such a time. The swelling of the knee-joint is usually most marked six to eight hours after the injury, and needs only to be distinguished from that due to a traumatic prepatellar bursitis. The swelling in the latter is quite superficial (Fig. 189), causing a more circumscribed bulging without obliteration of the depressions around the patella, as is the case in an effusion into the joint.

It must not be forgotten, however, that effusion into the prepatellar bursa may accompany a fracture of the patella (Fig. 189).

Fig. 190.—Comminuted Fracture of Patella (Side View) (Jefferson Medical College Hospital).

Crepitus and mobility of the fragments can be elicited before much swelling has occurred. In the majority of cases of transverse fracture a gap can be felt between the two fragments. When the fragments are pressed together, it causes great pain.

Prognosis and Results.—Although bony union has undoubtedly occurred, it is very rare in transverse fracture. In the oblique and longitudinal varieties it is the rule. In the majority of transverse fractures not operated upon the union is a fibrous one. The strength of this union depends directly upon the degree of separation of the fragments. Union occurs in thirty to forty days. The functional result may be perfect, even though the separation of fragments is from three to four inches (Fig. 192). This good function is due—(*a*) to the hypertrophy of the reserve apparatus previously referred to; (*b*) to the shrinking or contraction of the fibers of the quadriceps and the same process in the ligamentum patellæ.

Conditions which contribute toward poor results, as the statistics of Quinby, Lewissohn, and others show, are marked atrophy of the quadriceps, absence of fibrous union between the fragments, and adhesion of the upper fragment to the femur.

Union may occur at the time of the original fracture, but fail to take place if the bone be refractured, as frequently occurs in cases not operated upon. Even in favorable cases more or less fibrous ankylosis remains.

A fracture of the patella predisposes to refracture. The latter either occurs when the patient begins to walk or after some weeks. In rare instances it may occur years after the original injury. In recent cases the refracture is through the line of union; in older ones it takes place in the upper fragment. The prognosis is better in the latter variety.

Treatment.—The indications for treatment are: (1) To get rid of the hemorrhage into the joint; (2) to secure accurate coaptation of the fragments until union occurs; (3) to overcome the atrophy of the quadriceps and restore the function of the knee-joint.

The treatment of the joint-effusion is the first problem which presents itself, no matter whether the further treatment be operative or non-operative. The best method to secure speedy absorption of the blood in the joint is to elevate the limb upon a well-padded posterior splint and bandage the region of the knee firmly from below upward with a rubber elastic bandage. This should make firm and uniform compression, and not interfere with the circulation of the leg. The rubber bandage should be left in place for forty-eight hours. By this time the blood is usually absorbed. Instead of this method of hurrying the absorption, massage may be employed twice daily for five to ten minutes.

Many surgeons who use the operative treatment do not wait for the absorption of the blood, but operate as soon as possible after the injury. From my personal experience I believe that this is a perfectly safe mode of procedure. Aspiration of the blood is very unsatisfactory on account of the many clots.

In regard to which method of treatment to choose, operative or non-operative, it may be said that if every requirement of strictest asepsis can be secured, the most satisfactory results will be obtained by suturing the patella. The hemorrhage into the joint is at once disposed of, the apposition of the fragments is accurate, tilting is overcome, the periosteum does not get in between the fragments, and massage and passive motion can be begun earlier.

The additional advantages are that the chances of bony union are far greater; one can also repair the tear in the aponeurosis, and there is less danger of refracture. Operation is contra-indicated in elderly patients or where the contusion of the skin is such as to endanger the possibility of obtaining primary union of the external wound. The consensus of European, especially of German, opinion agrees with that of this country that the best results are obtained by open incision and suture in recent cases when the operation is properly performed.

Operative Treatment.—The time for operation has been discussed on p. 125. Many surgeons prefer to wait until the end of the first week. Experience has shown that it is perfectly safe to operate within the first twenty-four to forty-eight hours after the injury.

Incision.—Whether an incision which is curved upward or downward is employed is of no importance. Personally, I prefer a curved incision with the convexity upward. The dense fascia is then incised and the fracture exposed by turning down the flap.

Clearing the Fracture.—The blood-clots and liquid blood in the joint are washed out with hot sterile water or a weak solution of bichlorid (1:5000), followed by sterile water. The periosteum and torn strips of the aponeurosis which turn in between the fracture edges are now picked up with tissue forceps, removed, and held back by retraction.

Uniting the Fragments and the Torn Aponeurosis.—This can be done by metal sutures, such as silver or bronze aluminum wire, or by absorbable sutures, like chromicized catgut or kangaroo tendon. The general tendency at the present time is to employ the absorbable sutures, and of these, kangaroo tendon is to be preferred. It has been shown in a large number of cases that accurate suture of the lateral tears in the aponeurosis is of equal if not of greater importance than that of the patella itself. Metal sutures inserted through holes drilled through the upper and lower fragments or inserted in a circular manner around the patella are still extensively used. The general tendency, however, is to use an absorbable suture and unite the aponeurosis and periosteum, which are one structure in front of the patella, with two or more catgut or kangaroo-tendon sutures, and to repair the lateral tears by one or more sutures of the same material. One should always wear rubber gloves in operations of this nature. If they are not worn, the parts should be handled as little as possible with the fingers. Drainage is not employed. The external incision is sutured with fine catgut. The limb is wrapped with strips of sheet-wadding from the toes to the hip, and encased in a plaster cast extending over the area surrounded with sheet-wadding. The cast is left on for six weeks, at which time the fragments are usually firmly united, and daily massage of the atrophied thigh muscles and passive movements of the knee-joint are begun. Some surgeons advocate the removal of the cast or splint at the end of four weeks, and to begin massage and passive motion at this time. It is safer, however, and gives equally good, if not better, results, not to begin active treatment until the end of the sixth week.

Operative Treatment of Old Cases.—In old cases, where the fibrous union has stretched and the patient is unable to extend the knee or to walk without limping or to flex the knee at a right angle, operative measures often give much better functional use. The fibrous tissue is dissected away, and the fragments freshened, if necessary, with a saw and sutured with an absorbable or a metal suture. The upper fragment must often be detached from the femur, to which it is attached. In some cases it is better to remove the fragments and suture the patellar ligament to the quadriceps tendon. Bergmann and Pucet advise dividing the ligamentum patellæ at its attachment, moving it upward as far as possible, and then reattaching it by a metal suture. The Perraresi method is good. It consists in making a careful periosteal suture and then reflecting a square flap from the anterior fibers of the quadriceps tendon over the broken patella and suturing it to the patellar ligament below. This prevents eversion of the upper fragment. In a case in which it was impossible to approximate the two fragments of the patella, Keen partially divided the muscles and fascia above the upper fragment and then chiselled the tuberosity of the tibia loose, but leaving it attached by the fibrous tissue of the expanded tendon. These two maneuvers allowed approximation of the fragments, which were then wired. The result was very satisfactory.

Non-operative Treatment.—This is the best treatment to employ unless an operation under the most rigid aseptic surroundings can be performed, and by a surgeon thoroughly trained in asepsis. It is to be especially recommended in elderly people and in cases in which it is possible to get the fragments accurately approximated. The first indication after the limb has been placed upon a well-padded posterior splint extending from the hip to just beyond the heel* is to hurry the

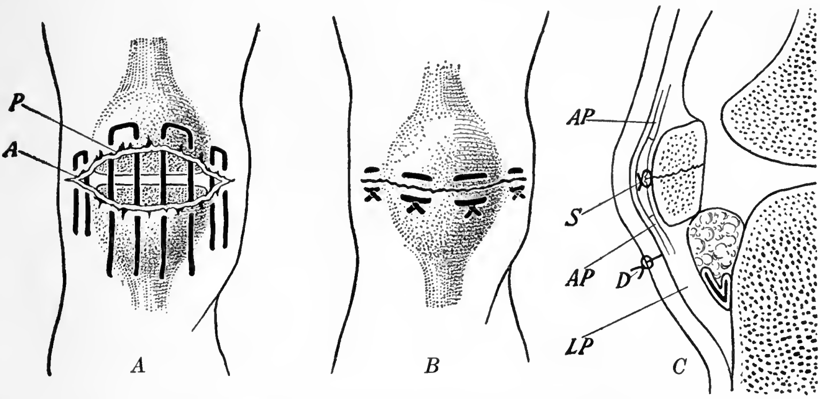


FIG. 191.—MODE OF SUTURE OF FRACTURE OF THE PATELLA.

A, Sutures are shown passing through the aponeurosis (*A*) and periosteum (*P*) together, being inserted in a mattress manner. *B*, Sutures tied. Note the fact that sutures are placed laterally, so as to unite the torn aponeurosis lateral to the patella. *C*, Sagittal section of knee-joint, showing relations after completion of suture: *AP*, Aponeurosis covering the quadriceps extensor tendon, which is in reality a continuation of the latter, and extends over the front of the patella, uniting with its periosteum; the suture (*S*) placed over the line of fracture unites this without passing through the patella itself, the latter step being in the majority of cases superfluous. *D*, cutaneous suture; *LP*, ligamentum patellæ.

absorption of the blood in the joint. This can be best accomplished by elastic compression or by use of massage. The result of aspiration is seldom satisfactory, but the removal of a small quantity of liquid blood will hasten the absorption of the remainder. Massage and elastic compression give the best results. Massage should be employed for fifteen minutes twice daily.

Approximation of the Fragments.—This should not be attempted until most of the effusion has disappeared, *i. e.*, toward the end of the first week. The upper fragment is first drawn down by elevating the limb, which has previously been placed upon a posterior wooden splint a little wider than the limb and extending from below the heel to the hip. This elevation of the limb relaxes the quadriceps extensor muscle. The

*The limb must be elevated and that portion of the splint upon which the heel rests should be liberally padded to avoid pressure upon the heel.

upper fragment is held down by a strip of zinc oxid adhesive plaster which is passed around the upper fragment like a loop and fastened to the sides and back of the wooden splint in such a manner as to hold the upper fragment. The lower fragment is held in a similar manner by a loop of adhesive plaster. In order to secure better apposition a third strip should be placed over the edges of the two fragments to prevent them tilting outward after they have been brought into apposition by the strips above and below them. Instead of a single strip above and below, it is better to use three or four strips of the same width and allow each one to cover the preceding one by two-thirds of the width of the latter in the same manner as one applies adhesive plaster in fractures of the ribs. The muscles of the thigh can be gently massaged twice daily for fifteen minutes. The adhesive plaster around and across the patella does not need to be removed until union has been secured, *i. e.*, at the end of six weeks.

Fig. 192.—Skiagraph of Fracture of Patella Three Years after Injury.
Note the wide diastasis of fragments which did not interfere with extension of leg (see text).

The limb is now placed upon a posterior molded splint or upon a short posterior wooden splint, or, instead of these, a circular plaster cast can be made extending from the groin to the ankle. It is split in the median line before it hardens, and thus forms a removable plaster splint. Such a splint can be covered with stockinette when it is hard, and lacing hooks fastened to leather strips are stitched to each cut edge. It can thus be worn whenever the massage is not being given. Instead of these an elastic or a leather kneecap can be used. The patient is allowed to put some weight upon the limb at the end of six weeks with the aid of crutches while wearing some form of removable splint. The knee should be thus protected for six months while walking. Passive and active motions of the knee-joint are begun at six weeks after injury. The crutches can be discarded after the eighth week and the patient allowed to walk with the aid of a cane. The removable splint and the cane are not used after the sixth month. The knee region is encircled by a flannel or rubber elastic bandage for two months. During this entire period all sudden movements should be avoided on account of the danger of refracture.

Results of Operative and Non-operative Treatment.—Statistics have been published to compare these two methods in fractures of the patella. The most instructive series of cases is that published from the clinic of Czerny by Lewissohn of 40 cases treated from 1878 to 1905 in the Heidelberg clinic. Examination was made in 26 cases. Of these, 8 had been operated upon. In 6 there was union and in 2 the wires had cut through. In 18 cases not operated on bony union had taken place in 3, while in 10 the separation of fragments was as large as when the cases had been admitted. All published results of recent years show that accurate bony union does not always mean a good functional result. This is well illustrated in a case recently seen by the writer and shown in Fig. 192. The patient had been treated by the non-operative method, and although examination three years later showed a diastasis of nearly three inches, extension and flexion of the knee-joint and ability to stand and walk long distances were perfect. Some of Czerny's best functional results were in cases in which the separation was very wide. One patient had marched twenty miles daily in the army for two years. The other walked up and downstairs all day without any discomfort. Of 18 cases not operated upon, the result was excellent in 8. In only 2 of these had bony union occurred. Of 8 cases operated on 2 showed a poor result. Bony union had occurred in both of these cases. Only one of the 8 cases operated on gave an excellent functional result, and in this one a considerable separation existed.

These results in a European clinic are corroborated by those of W. C. Quinby, of 30 cases treated in the Massachusetts General Hospital, which were examined as to the final result out of a total of 75 cases, treated by both methods between 1898 and 1904. Of these 30, 6 were treated without suture, while in the remaining 24 there were 26 sutures, 2 cases having a double fracture. With one exception they entered within a week of the injury. In 9 of these sutured cases a second operation was done, 7 times for refracture and 2 to remove the wire.

Unsutured, 6 cases.

Result:		Per Cent.
Perfect,	3	50.0
Fair,	1	16.5
Poor,	2	33.5
Serviceable knees,		66.5

Sutured, 24 cases, 26 operations.

Result:		Per Cent.
Perfect,	17	65.5
Fair,	5	19.0
Poor,	4	15.5
Serviceable knees,		84.5

Cases in which voluntary extension and flexion were normal, 180 degrees and 34 degrees respectively, with perfect function, and not over $\frac{2}{5}$ inch atrophy of the quadriceps, were classed as perfect. Those where flexion was possible to a right angle or a little less, and in which there was no limp or trouble in walking on the level, were classed as fair; while those who could not flex to a right angle and who limped or became easily tired on the level and had to use a cane or go upstairs one step at a time were classed as poor.

Fractures of the Upper End of the Tibia.—Fractures of the upper end of the tibia usually extend into the knee-joint. The most frequent form is that in which the line of fracture is oblique and results in the separation of either the internal or external tuberosity from the remainder of the bone (Fig. 193). In addition to the oblique fractures of the tuberosities, transverse and longitudinal fractures occur, but are comparatively infrequent. A form of compression fracture has also been described by Wagner of Königshütte, in which there is a fracture of either tuberosity and more or less marked crushing of the head of the tibia after a fall upon the foot ("e" of Fig. 193).

Diagnosis.—The diagnosis of fracture of the upper end of the tibia is often impossible without the aid of an anesthetic and the *x*-ray. In almost every case the accompanying effusion into the knee-joint is so marked after a few hours as to render an examination very difficult.

In fractures involving one of the tuberosities abnormal mobility of the knee, either in an inward or outward direction, will be found when the knee is manipulated in the manner shown in Fig. 188. There is great pain on pressure over the condyle. If the internal tuberosity is involved, there is abnormal mobility at the knee in an inward direction, or the limb is found in a genu varum position. If the external tuberosity is broken, abnormal mobility in an outward direction is to be found and the limb is held in a genu valgum position. Unless the swelling of the knee-joint is too great, one can palpate the displaced condyle and in some cases elicit distinct crepitus.

If both tuberosities have been broken and the shaft has been displaced upward between them, there is widening of the knee-joint.

Separation of the upper epiphysis of the tibia, of which twenty-six cases have been reported, is, like that of the lower epiphysis of the femur, a serious and often fatal injury. The swelling of the knee-joint is usually considerable. Mobility of the epiphysis, most noticeable in a lateral direction, is, as in other epiphyseal separations, the most trustworthy sign, according to Poland. Crepitus of a soft, muffled character can be detected in many of the simpler cases in which mobility of the epiphysis is present. Dislocation of the knee is scarcely known in children, and the free movement of the joint in cases of separation suffices to exclude this form of injury. When there is little or no displacement or mobility, the injury may be mistaken for a sprain of the knee. Osgood has called attention recently to a peculiar partial separation of the tongue-shaped portion of the upper tibial epiphysis in young athletes. Clinically, acute pain is felt in the knee, referred to a point below the patella. It is accompanied by slight swelling of the joint and there is considerable weakness on exertion.

Avulsion of the tubercle of the tibia occurs in the young. The

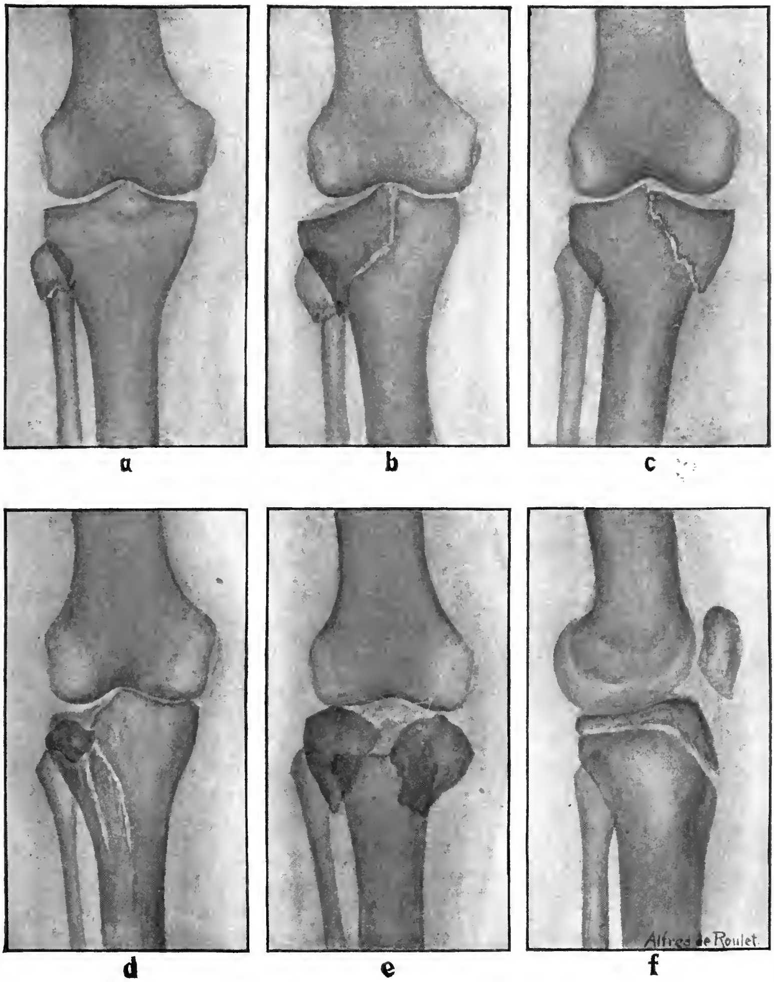


Fig. 193.—Various Forms of Fractures of the Upper End of the Tibia and Fibula Near the Knee-joint.

a, Fracture of the upper end of the fibula alone. b, Fracture passing through the outer tuberosity of the knee-joint, accompanied by fracture of the upper end of the fibula close to its head. c, Fracture passing through the inner tuberosity of the tibia, with displacement of the leg outward, resulting in a genu valgum position. d, Multiple crushing fracture of the outer tuberosity of the tibia. e, Multiple crushing fracture of the upper end of the tibia, extending into knee-joint. The lower fragment, composed of the shaft, is forced upward between the two upper fragments, composed of the tuberosities. f, Side view of separation of upper epiphysis of tibia and the beak-shaped process of same.

diagnosis can be made by the recognition of independent mobility of the tubercle, inability to use the limb, and swelling of the knee-joint.

In some cases there is only local pain and tenderness, and the diagnosis cannot be made without the aid of a skiagraph.

Fractures of the Upper End of the Fibula.—These occur either through muscular action of the biceps or, more commonly, through forcible adduction of the leg. The injury may be recognized by the presence of pain just below the head of the fibula, accompanied by the presence of a small, hard mass, movable from side to side, which is raised by extension of, but sinks after flexion, of the knee-joint. There is also abnormal lateral mobility of the knee-joint. Not infrequently the injury is followed by paralysis of the muscles (peronei) supplied by the peroneal nerve, causing inability to raise the outer border of the foot.

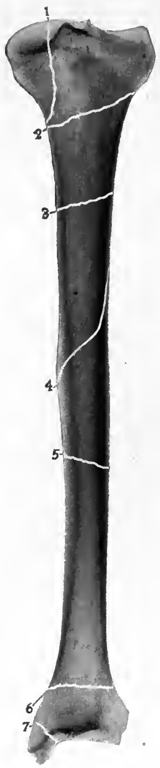


Fig. 194.—Location of Most Frequent Fractures of Tibia.

1, Of inner tuberosity, extending into joint; 2, junction of head and shaft; 3, oblique of upper third of shaft; 4, spiral of shaft; 5, oblique of middle of shaft; 6, supramalleolar; 7, through internal malleolus.

Fig. 195.—Location of Most Frequent Fractures of Fibula.

1, Through shaft just below head; 2, oblique of lower third of shaft; 3, supramalleolar; 4, of external malleolus.

FRACTURES OF THE SHAFT OF THE TIBIA.

These occur more frequently after direct (by being run over or by a heavy body falling on the limb) than after indirect (sudden abduction or adduction of foot) modes of injury. Both bones of the leg are usually broken after indirect violence. Complete fractures are far more frequent in adults than in children.

The line of fracture is most often oblique (Fig. 194), although spiral fractures have been found in about one-seventh of all the cases. This is important to diagnose by the use of the x-ray, owing to the fact that in the spiral form the fracture is much more difficult to reduce completely.

In the oblique form the line of fracture runs from below and anteriorly, backward and upward, so that the upper fragment is often displaced forward to such an extent as to lie directly beneath the skin.

Comminuted fractures, especially of the lower end of the tibia and fibula, are not uncommon.

The diagnosis of a fracture of the shaft of one or both bones of the leg is, as a rule, not difficult.

In many cases the deformity at the point of fracture and the outward rotation of the foot will permit a diagnosis to be made from inspection alone. In some cases of compound fracture the ends of the fragments project through the skin. By grasping the limb gently while the assistant supports the knee or ankle abnormal mobility and crepitus can be readily elicited.

Shortening of the limb can be estimated by measurement from the upper border of the inner tuberosity of the tibia to the tip of the inner malleolus. The finger should also be passed along the tibia and fibula

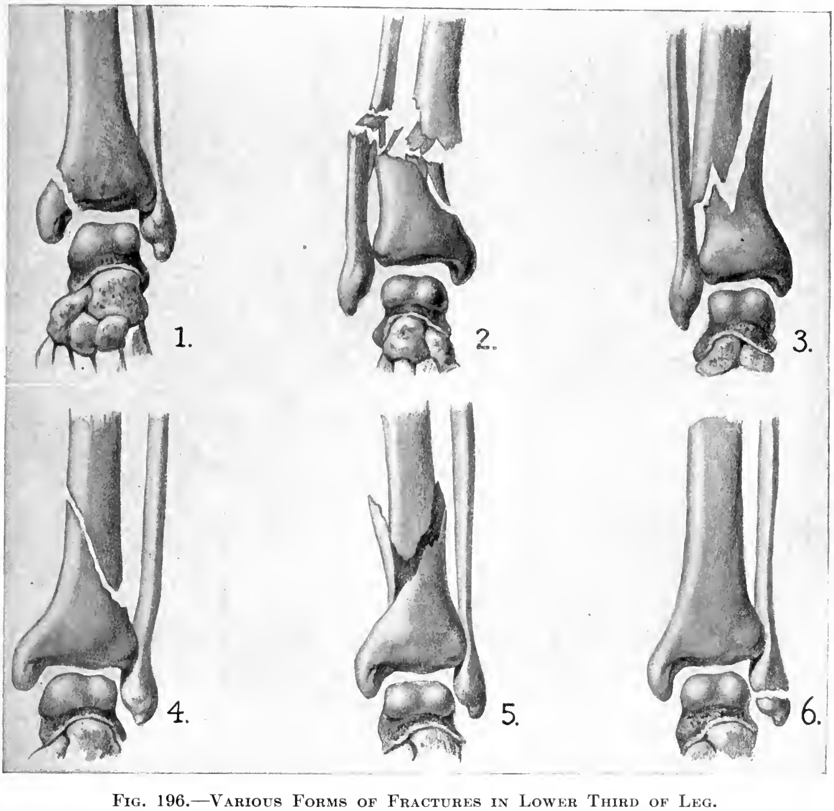


Fig. 196.—Various Forms of Fractures in Lower Third of Leg.

Wash drawings made from skiagraphs. 1, Fracture of internal malleolus; 2, comminuted fracture of tibia and fibula at junction of lower and middle third; 3, oblique fracture of tibia, with displacement of upper fragments outward; 4, oblique fracture of tibia without displacement; 5, spiral fracture of lower third of tibia; 6, fracture of external malleolus.

wherever they lie beneath the skin, in order to detect any irregularity. In a few cases where the broken ends are dentated and but little displaced, one must be content, in the absence of a skiagraph, with making a diagnosis from the presence of localized pain and swelling followed by loss of function.

When both bones are broken, the abnormal mobility is naturally much greater than is the case if the tibia alone is fractured.

Isolated fractures of the upper and middle thirds of the shaft

of the fibula are relatively rare. The diagnosis of such fractures depends upon the localized pain and the elicitation of crepitus and abnormal mobility on pressure.

It is of the greatest importance to combine the use of the x-ray with the above outlined external examination. It reveals many cases of incomplete or subperiosteal fractures where none were suspected. It also yields much information as to the degree of displacement and the direction of the line of fracture, whether spiral, oblique, or transverse.

Fig. 197.—Skiagraph of Spiral Fracture of the Tibia.

Fig. 198.—Compound (Gunshot) Comminuted Fracture of the Lower Third of the Tibia and Fibula.

The line passing across the upper portion of the plate is due to a defect. The black particles of the bullet fragments are well shown lying over the front of the tibia.

Separation of the lower epiphysis of the tibia is more frequent than is that of the upper. Deformity is the most marked sign, the foot and the epiphysis being displaced backward. The internal malleolus preserves its normal relations with the foot, but not with the rest of the leg or the external malleolus.

In gunshot fractures (Fig. 198) of the leg the comminution of the tibia is usually much more extensive than is suspected from external examination alone.

INJURIES IN THE VICINITY OF THE ANKLE-JOINT.

In the examination of a patient who shows evidences of injury in the vicinity of the ankle-joint, such as swelling, deformity, loss of function, etc., the following conditions must be thought of in the order given:

1. Fractures of the lower ends of the tibia and fibula (Pott's fracture).
2. Dislocations at or near the ankle.
3. Fractures of the tarsal bones.
4. Rupture of the tendo Achillis.
5. Sprains and sprain fractures (mastoid fractures) of the ankle.

Fractures of the Lower End of the Tibia and Fibula.—These are all given the name "Pott's fracture." They may be the result either—(*a*) of forcible abduction or eversion of the foot, or (*b*) of inversion or adduction. If the sole or main movement is eversion, the internal malleolus is broken, and if the force continues to act, it also causes the external malleolus to be broken. In the second variety, *i. e.*, fracture by inversion, the first effect of the force is to break the fibula (external malleolus). If the movement continues, the internal malleolus or a greater portion of the tibia is broken off.

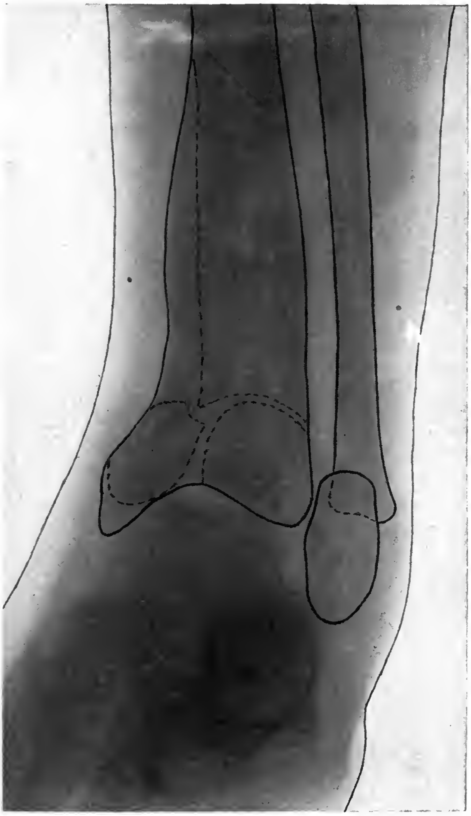


Fig. 199.—*x*-Ray of Case of Fracture of Both Bones of the Leg, the Exterior Pictures of Which are Shown in Figs. 203 and 204.

Note the voluminous callus-formation in the tibia, and the displacement inward of both lower fragments and of the foot.

Diagnosis.—There is usually no difficulty in making a diagnosis. The ankle-joint is greatly swollen, the depression normally present in front of and behind the malleoli being obliterated. The foot is displaced outward, and the internal malleolus is prominent. This deformity will often persist and become a cause of disability after healing of the fracture (Fig. 205). There is also backward displacement of the foot (Fig. 200).

These displacements may be so marked as to resemble a true dislocation of the ankle at first glance. Abnormal lateral and anteroposterior mobility may be ascertained by grasping the sole of the foot (Fig. 202) with one hand and moving it inward and outward, or backward and forward, while the other hand steadies the leg. There is great tenderness between the tibia and fibula at the front of the ankle, and over the points of fracture in the malleoli.

If the fibula alone is broken, abnormal mobility and crepitus may be elicited by pressing its tip inward with the index-finger of one hand (Fig. 201), while a finger of the other hand is placed at the seat of fracture.

In some cases of Pott's fracture the foot will move inward instead of

Fig. 200.—Fracture of Both Bones of the Leg with Marked Backward Displacement.

outward. The degree of backward displacement can be measured by the difference in the distance from the front of the ankle to the cleft between the first and second toes, as measured on the sound and injured foot. There is not always complete loss of function. In fractures of the external malleolus alone the patient may walk quite well.

Treatment of Fractures of the Leg.—The treatment of a simple fracture of one or of both bones of the leg depends first upon whether swelling is present, and second upon the amount of displacement of fragments and our ability to keep them in apposition after reduction.

The Presence or Absence of Swelling.—If the case is seen within a few hours after the injury and but little if any swelling is present, the

Fig. 201.—One of the Methods of Examination in Order to Determine a Fracture of the External Malleolus.

The method consists in making pressure upon the tip of the malleolus, as shown in the illustration, with the two fingers of one hand, while the other hand is placed at the suspected point of fracture. The hand placed over the tip presses it in and allows it to spring back, thus establishing a kind of lever action, which permits the other fingers to detect readily a false point of motion.

following is a perfectly safe and justifiable method of treatment. The limb is wrapped with strips of sheet-wadding from the toes to the middle of the thigh, and a circular plaster-of-Paris cast is applied extending over

Fig. 202.—Method of Examination for Fracture of the Tibia or of Both Bones of the Leg Close to the Ankle-joint.

The foot is grasped by the left hand of the examiner when fracture of the left leg is suspected, while the right hand grasps the region just above the malleoli, so as to steady the limb during the time that the foot is being turned toward or away from the median line of the body, in order to determine false point of motion and crepitus.

the same area. Before the cast is dry it is cut open along the median line in front to allow for any possible swelling. The cast is best applied while the patient is under the influence of an anesthetic, so as to permit reduction of the fragments to be made by traction upon the foot.

In ten days to two weeks the cast should be removed and a fresh one applied. The second cast does not require to be cut open, and can be left on the limb until the end of the fourth week. It is then removed, and if union is complete, no further cast need be worn. If there is still some motion at the point of fracture, a third cast can be applied, extending from the toes to just below the knee, and removed at the end of two weeks.

Massage of the limb and passive and active motion are now begun.

Fig. 203.—View from Outer Side of Deformity Following Pott's Fracture.

Note the prominence of the external malleolus, due to the displacement outward of both upper fragments, that is, of the tibia and fibula.

Fig. 204.—Anterior View of Deformity Following Pott's Fracture.

Note the change in the axis of the right or injured limb from the middle of the leg downward. This deformity was due to the displacement inward of the lower fragments of the tibia and fibula respectively.

This method is especially applicable to fractures of the tibia or fibula alone.

If Considerable Swelling or Displacement is Present.—The safest plan in the treatment of this class of fractures of the bones of the leg is to immobilize the limb in some form of temporary splint. For this purpose the following splints are to be recommended: (1) The fracture-box (p. 271); (2) the blanket splint (p. 112), with two lateral wooden splints; (3) the pillow splint, with two lateral wooden supports; (4) a posterior molded plaster splint (Fig. 68) extending from the toes to the middle of the thigh; (5) the Volkmann trough splint. Which of these is to be used is to a great extent a matter of individual experience. I have obtained very satisfactory results after using the fracture-box and blanket splint, both of which allow of frequent inspection of the limb and the application of ice to reduce the swelling. The posterior molded splint is to be warmly recommended for those cases in which there is much tendency for the displacement to recur. It is especially useful in the temporary treatment of fractures in alcoholics, who are apt to twist the limb out of the other forms of retentive apparatus and convert the fracture into a compound one. The advantages of the blanket or pillow splints are that they can be readily made in any household and give excellent fixation.

When such a fracture with considerable swelling or displacement of

FIG. 205.—LATERAL VIEW OF AMOUNT OF FIXATION OF ANKLE-JOINT FOLLOWING MANY INJURIES IN CLOSE PROXIMITY TO THE SAME.

The lower one of the two limbs shows the degree of extension of the foot on the uninjured side. On the side of the fracture it can be readily seen that the amount of extension is practically lost, and that the foot is fixed at a right angle to the long axis of the leg.

fragments is first seen, the limb should be thoroughly washed and dried. If any blebs are present, they should be opened with every aseptic precaution, and then dusted with some mild antiseptic powder (such as 1 part of salicylic acid to 16 parts of powdered boric acid) and covered with sterile gauze.

A good way to reduce the swelling is to elevate the limb and apply an ice-bag. The latter should always be separated from the skin by several thicknesses of gauze and should not be applied continuously. It can be left on for an hour and not reapplied during the following half-hour.

Any marked displacement should be corrected at the time the limb is placed in the temporary splint, but the efforts toward more accurate approximation should be postponed until an anesthetic is given for the application of the permanent dressing.

The limb should be frequently inspected until all the swelling has gone, for evidences of injury of the blood-vessels and of traumatic gangrene of the skin and soft tissues.

The swelling will usually have disappeared by the end of the first week. The two indications at such a time are, first, to correct the displacement, and, second, to maintain the apposition until firm union has occurred.

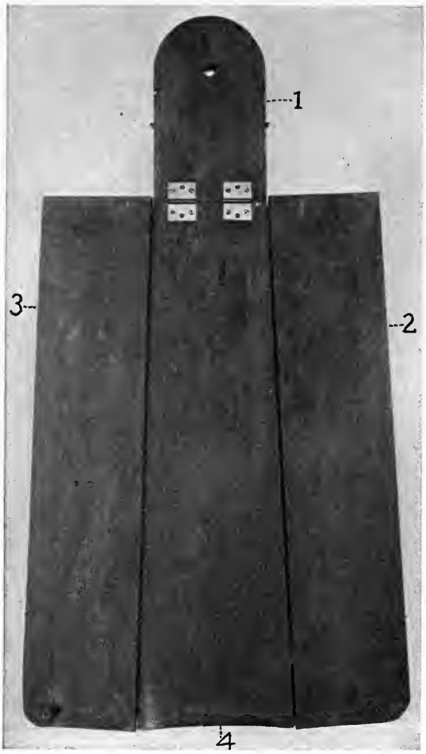


Fig. 206.—Fracture-Box for Temporary Treatment of Fractures of the Tibia or Fibula, Opened up.
1, Foot portion; 2 and 3, side pieces.

Reduction of Fragments.—The pain of the manipulations necessary to effect reduction and the reflex muscular spasm necessitate the administration of a general anesthetic, which should be continued during the application of the plaster cast.

The reduction of displacement is accomplished, in the majority of cases, by traction upon the foot and countertraction (by an assistant) upon the lower portion of the thigh or knee.

The foot of the injured limb is grasped at the heel with one hand, while the other hand is placed around the foot close to the base of the toes. Traction should be made in the direction of the long axis of the limb. During this manipulation the knee is supported by an assistant, and if required, countertraction can be made in an upward direction until no deformity is visible or palpable.

It has been proposed by Lane and others that unless accurate approximation can be secured, an incision should be made over the seat of fracture and the fragments reduced. Such a step is seldom necessary. The question of operative interference in recent simple fractures of the bones of the leg only arises in connection with oblique or spiral fractures of the shaft of the tibia, with or without accompanying fracture of the fibula, in which there is a marked tendency to recurrence of displacement of fragments. This question has been fully discussed on p. 123. In these oblique or spiral fractures reduction is difficult, and in some cases the displacement will recur as soon as traction has ceased. Operative interference is indicated and has been followed by excellent results (p. 125).

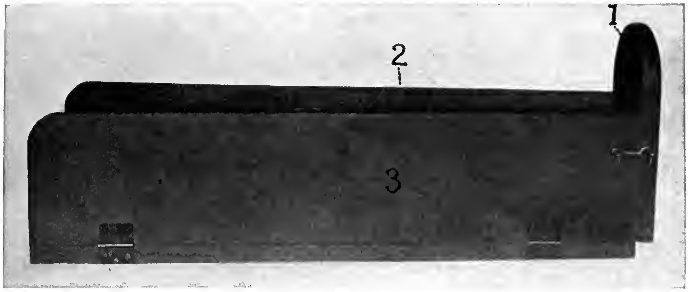


Fig. 207.—Lateral View of Fracture-box for Use in Temporary Treatment of Fractures of the Leg.

1, Foot-piece; 2 and 3, side pieces, which can be separated from each other, as shown in Fig. 206.

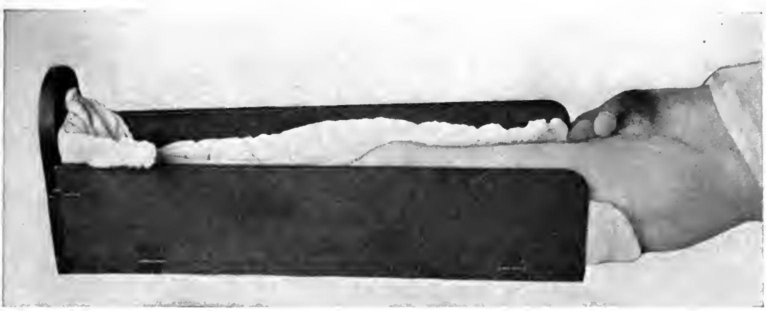


Fig. 208.—Fracture-Box Used in Temporary Treatment of Fractures of Leg (Tibia or Fibula).

The box is padded by cushions made by inclosing ordinary cotton batting in cheese-cloth.

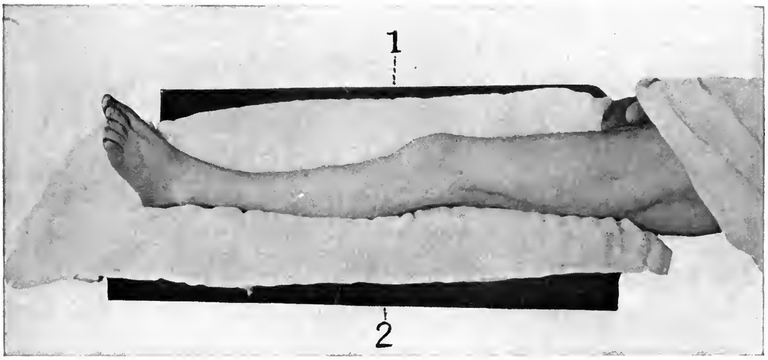


Fig. 209.—Fracture-Box in Use for Treatment of Fractures of Both Bones of the Leg until Cast can be Applied.

1 and 2, Side pieces open.

The treatment of compound fractures has been fully discussed on pp. 131 to 135.

The ambulatory treatment of fractures of the leg has been referred to previously (p. 122). The best treatment for all recent simple fractures of one or of both bones of the leg, including the variety known as Pott's

Fig. 210.—Improper Method of holding Foot before Application of Cast for Fracture of Leg or Thigh.
The knee is hyperextended and the foot is forcibly extended, so that when the cast is put on the foot remains in a faulty pes equinus position.

fracture, is to inclose the limb in a circular plaster-of-Paris cast. The most favorable time to apply such a permanent dressing is when all of

Fig. 211.—The Proper Method of Holding Limb during Application of Casts to Leg or Thigh.
The patient's hips are brought to the edge of the table, the normal limb rests upon a chair, one assistant flexes the knees slightly, grasping the leg which is to be inclosed in the cast above and below the knee-joint, as shown in illustration; the second assistant is seated upon a chair and holds the foot exactly at right angles and slightly adducted. One hand supports the heel and makes extension while the other keeps the foot flexed.

the swelling has disappeared, *i. e.*, at the end of the first week. The fragments having been reduced in the manner just described, the cast is applied.

The limb should be covered with sheet-wadding or a flannel bandage from the toes to the middle of the thigh. The number of plaster bandages employed can be greatly decreased by using strips of thin cypress wood, which are allowed to soak in hot water before using, or by inserting a number of strips of tin. One assistant who is seated makes traction upon the foot, as shown in Fig. 211. This assistant should be especially cautioned to keep the foot at a right angle to the leg and a little adducted. He should also be warned to make traction in the long axis and not to pull the foot upward, thus causing a backward bowing of the leg. A second assistant supports the knee, flexing it slightly. The patient's hips are brought to the edge of the table, and the foot of the non-injured limb allowed to rest upon a chair.

The cast is removed at the end of the fourth week after the injury. If union is not firm, a second short cast is reapplied, extending from the base of the toes to the knee, and removed in ten days to two weeks. Massage and active and passive motion are begun as soon as union has been secured. The patient is allowed to be up and about on crutches as soon as the first plaster cast has become dry. If the injury is followed by a flat-foot, a steel insole should be worn. Old fractures with deformity are most satisfactorily treated by osteotomy. One should always bear in mind the possibility of pulmonary embolism in these fractures.

FIG. 212.—DUPUYTREN'S SPLINT. Note length of splint; position of straps; arrangement of padding; space between foot and splint (Scudder).

There is not infrequently a tendency to outward displacement of the foot in a Pott's fracture which it is difficult to correct by traction. Such cases are very successfully treated by the Dupuytren splint (Fig. 212) until a plaster cast can be applied.

FRACTURES OF THE TARSAL BONES.

Fractures of these bones, like those of many other portions, have been found far more frequently than was thought before the use of the x-ray. Many cases of tarsal fracture have been treated for sprains of the ankle. It is only when the recovery was slow or the injury was followed by a traumatic flat-foot that the surgeon began to suspect that a more serious condition had been present at the time of the original injury.

Fractures of the other tarsal bones occur so rarely that one need consider only those of the astragalus and os calcis.

Fractures of the os calcis are due to compression, in the majority of cases. The patient falls from a height to the ground on to a hard substance. The os calcis is crushed between the astragalus and the ground. In 59 of 63 cases collected by Cabot and Binney[73] the injury followed a fall from a height, and 4 were due to direct violence.

There are three general types of fracture of the os calcis:

1. That in which the fracture has been confined largely to that portion lying behind a vertical plane through the middle of the body of the astragalus. There are three varieties of this "heel fragment" type: (*a*) Cases with one large heel fragment (Fig. 216); (*b*) cases of small heel fragments. In this variety, also called avulsion fracture, the sudden contraction of the calf muscles pulls the fragment off. At times the tendo Achillis itself is torn from its attachment to the os calcis at the same time as occurred in the case shown in Fig. 216; (*c*) cases showing only fissures in the bone.

FIG. 213.—X-RAY OF NORMAL FOOT AND ANKLE-JOINT VIEWED FROM THE OUTER SIDE.
F, Fibula; T, tibia; 1, astragalus; 2, os calcis; 3, scaphoid; 4, cuboid; 5, external cuneiform.

2. The second type is that of comminution of the anterior half of the os calcis.

3. The third type includes all the cases of extensive comminution of the bones. As has been correctly said by Cabot, the bone is literally shattered. In one of my own cases the pulpification of the bone was even more extensive than that of the case shown in Fig. 214.

Fractures of the Astragalus.—These can be conveniently divided into—(*a*) those of the neck and (*b*) those of the body. The former of the two is the most common fracture of the astragalus. They may follow sudden dorsal flexion or forced supination or pronation of the foot. It may be due to a fall from a height or a direct violence. Fractures of the body of the astragalus are usually the result of a crushing force like those of the body of the os calcis, and they are often associated with fractures of the latter bone (Fig. 214).

The variety of fractures is considerable, varying from two large fragments (Fig. 215) to complete comminution of the bone.

A fact of considerable importance in the interpretation of skiagraphs of fractures of the astragalus is a knowledge of the presence, in many normal individuals, of a little bone known as the os trigonum.[74]

It may occur detached from the astragalus or be attached to it as a process on its posterior aspect (Fig. 215).

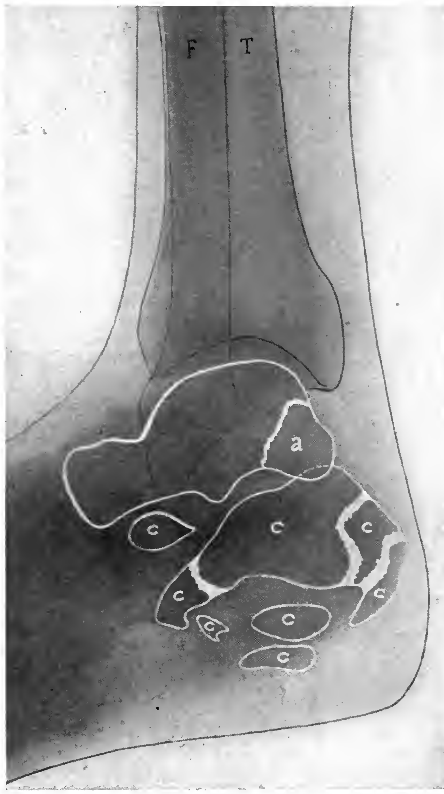


FIG. 214.—COMPRESSION FRACTURES OF THE ASTRAGALUS AND OS CALCIS, FOLLOWING A FALL OF EIGHTY FEET.

F, Outline of fibula; T, tibia; a, posterior fragment of fractured astragalus. The various letters c represent the comminuted fragments of the fractured os calcis

Diagnosis.—Ehret,[75] in a series of 47 cases, found that only three had been correctly diagnosed immediately after the injury. On account of the swelling and pain around the ankle (Fig. 217) a diagnosis can seldom be made without the routine use of the *x*-ray in every injury in this region.

In some cases it is possible to obtain abnormal mobility in fractures of the os calcis by grasping the heel between the thumb and index-finger and moving it from side to side.

The swelling with obliteration of the depressions (Fig. 217) normally present around the ankle does not differ from that characteristic of a sprain of the ankle or of a Pott's fracture. If there is extensive comminution of the os calcis or astragalus, the malleoli may be a little lower than normal.

In the avulsion or tearing variety of "heel fragment" fractures the foot cannot be extended, and as in the patient whose skiagraph is shown in Fig. 216, the fragment caused a projection above the heel which was of the consistency of bone.

The *x*-ray must always remain our most reliable means of diagnosis at the time of injury. At a later period the chief symptoms are a painful flat-foot, ankylosis of the ankle-joint, pain, and difficulty in pronating and supinating the foot.

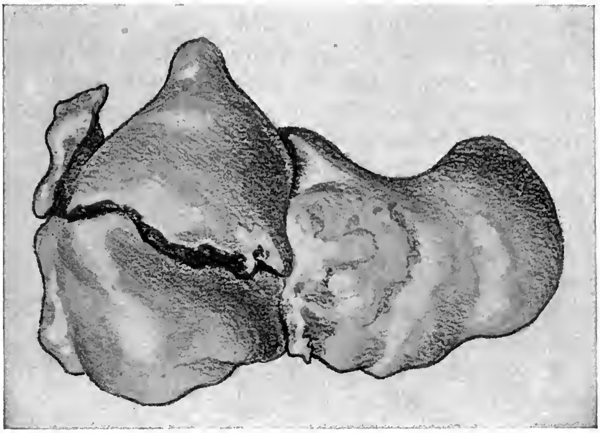


FIG. 215.—VIEW FROM ABOVE OF FRACTURE OF THE ASTRAGALUS. Showing line of fracture passing through articular surface which faces ankle-joint.

FIG. 216.—FRACTURE OF OS CALCIS (X-RAY) BY MUSCULAR VIOLENCE.
The white arrow indicates the direction of traction of the gastrocnemius and soleus muscles. The black arrow points to the characteristic elevation of the skin caused by the displacement upward of the fragment in such cases. 1, Fragment of os calcis; 2, main portion of bone; 3, astragalus; 4, 5, and 6, tarsal bones (cuboid, scaphoid, and cuneiform, respectively).

The prognosis of fractures of the tarsal bones is not favorable, even though the lesion has been recognized at the time of injury. Even in the most favorable there is some limitation of lateral motion. The outlook is better in those cases of the os calcis in which there is a large heel fragment than if the bone is comminuted.

Avulsion fractures often give a poor result unless the fragment is sutured (see Treatment).

The average disability in Cabot's cases was a year and a half. It is greater in fractures of the astragalus than in those of the os calcis.

The most frequent sequel is stiffness of the ankle-joint and traumatic pes valgus.

Infection is frequent in compound fractures.

Treatment of Recent Cases.—The treatment does not differ from that of a Pott's fracture until the greater part of swelling has disappeared.

The skin of the foot and lower portion of the leg should be thoroughly cleansed and covered with gauze. This is necessary on account of the possibility of necrosis of the skin of the heel and infection of the bruised soft tissues around the heel. Such a complication with septic symptoms occurred in a case I saw in consultation and necessitated amputation. The foot should be placed in a well-padded fracture-box or upon a posterior splint of the Cabot or Volkmann type. Ice-bags should be applied over the sides of the heel. Absorption of the extravasation in the soft tissues can often be hastened by light massage, but it is contra-indicated if fragments lie close to the skin. After eight to ten days a circular plaster cast can be applied extending from the toes to the knee. An anesthetic should be given during the application of the cast, the foot being held flexed at right angles (Fig. 211) and sheet-wadding freely used around the ankle. The cast should be worn for eight weeks.

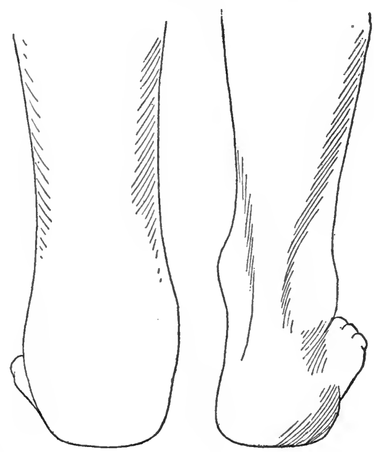


Fig. 217.

Outlines of normal ankle shown on the right, and of characteristic obliteration of depressions on either side of the tendo Achillis which occurs in severe sprains of the ankle-joint, with or without fracture of either bone of the leg or fractures of the tarsal bone.

At the end of this time the patient is gradually permitted to step upon the injured foot. If any tendency to pes valgus exists, it is advisable to wear a steel insole.

Passive and active motions are begun at the end of the eighth week, and can be greatly aided by the use of some mechanic device like the Krukenberg pendulum or one of the Zander machines adapted to this purpose. Cases requiring special consideration are the following: If the displacement of fragments is such as to endanger the vitality of the skin, an incision should be made over them. The fragments can either be replaced and sutured to the remaining bone, or they can be completely removed. Fractures of the neck of the astragalus with rotation of the posterior fragment are usually followed by great limitation of the movements of the ankle-joint. This might be greatly improved by an open reduction.

In cases of avulsion fracture (Fig. 216) with detachment of a small heel fragment the best non-operative treatment is to place the foot in a

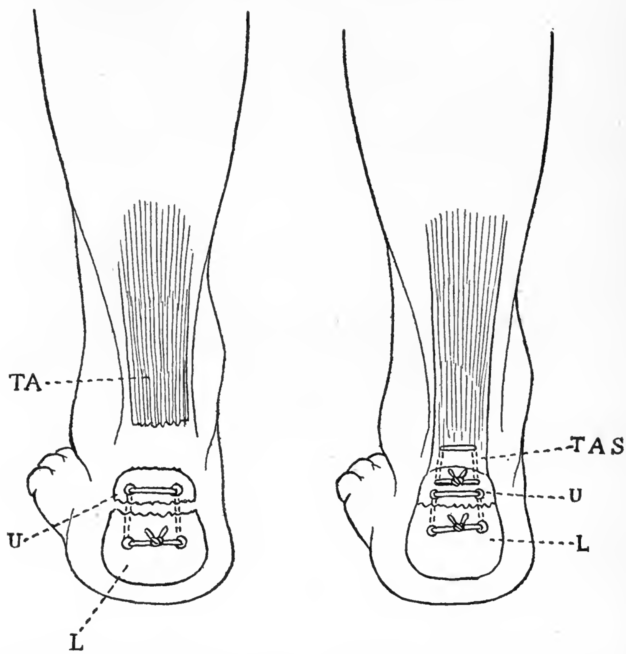


FIG. 218.—METHOD OF SUTURING FRAGMENTS OF OS CALCIS IN A CASE OF TEARING FRACTURE OF TUBEROSITY (FIG. 216).

This figure also shows the method of suturing the tendo Achillis when it is torn away from the upper fragment. TA, Tendo Achillis; U, upper fragment of os calcis; L, lower fragment. The tendo Achillis is shown as torn away from the upper fragment, and a kangaroo-tendon suture is shown *in situ* holding the two fragments together. TAS, Tendo Achillis sutured to the upper fragment by kangaroo tendon.

position of complete extension, after an attempt has been made to reduce the fragment by manipulation. A far more satisfactory method is to hold the fragment in position by an absorbable suture like kangaroo tendon, a hole either being drilled through the fragment and the remainder of the os calcis (Fig. 218), or the latter is united with the tendo Achillis by a mattress suture as I did in one case.[76] The same principle has been applied to fractures of the os calcis involving a larger heel fragment by Carless[77] and by Cabot.

FRACTURES OF THE METATARSAL BONES.

These are usually due to direct violence, as occurs when a heavy weight falls upon the dorsum of the foot. Another example of direct violence is a fracture following a crushing injury, as in being run over. A number of cases have been reported[78] where the fractures occurred in soldiers after long marches or in jumping or dancing. In the latter two instances the injury is the result of indirect violence. Such fractures may be complete or incomplete.[79] The second left metatarsal is most frequently involved in these painful foot swellings in soldiers.

Fig. 219.—Method of Examination for Fracture of a Metatarsal Bone. The foot is grasped between the fingers of the two hands in order to determine the false point of motion and crepitus.

In indirect violence, such as follows dancing,[80] jumping, or sudden twists of the foot, the fifth metatarsal bone is most often involved.

There is but little tendency to displacement except when several bones are broken at the same time, and then it is toward the dorsum of the foot. The diagnosis is made in fractures by direct violence by the presence of severe well-localized pain, swelling, and not infrequently crepitus and abnormal mobility.

In those due to indirect violence (second, third, and fifth) there is pain when the patient endeavors to put pressure upon the toes or tries to invert the foot. Jones[80] has found that the ordinary signs of fracture, such as crepitus, deformity, or abnormal mobility, are usually absent. The history is of importance in these cases.

A skiagraph should be made in every case. One should, however, remember the bony anomalies of this region to which Dwight[43] has called attention. These may lead to a diagnosis of metatarsal fracture when only an anomaly is present. The two structures are—(*a*) the os intermetatarseum, which may appear as a separate bone at the base of the first or second metatarsal bones, or (*b*) a separate tuberosity of the fifth metatarsal bone.

Fracture of the metatarsal bones is liable to be followed by a traumatic flat-foot on account of the sinking of the arch, or painful large calluses on the sole of the foot may interfere with walking.

The **treatment** in simple fractures is by immobilization in a posterior metal or plaster splint for four weeks. If there is continual pain upon walking after this injury, a steel insole will often give great relief.

The treatment of compound fractures does not differ from that of other bones.

FRACTURES OF THE PHALANGES OF THE TOES.

These are usually the result of direct violence, such as being run over or the fall of a heavy weight upon the toes. The diagnosis is readily made by the presence of abnormal mobility and crepitus upon manipulation. The *x*-ray will usually show a transverse or a comminuted fracture.

The treatment is similar to that of the phalanges of the hand, *i. e.*, immobilization upon a plantar splint which has the shape of the sole of the foot.

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CHAPTER XXV.

SURGERY OF THE JOINTS.

Clinical part by Robert W. Lovett, M.D. Pathology by Edward Hall Nichols, M.D.

Pathology of Diseases of the Joints.

By Edward Hall Nichols, M.D.,
BOSTON.

Lesions of joints can be divided practically into four different classes: first, those due to acute traumatism which does not produce any opening into the joint cavity which might give entrance to suppurative bacteria; second, those due to the entrance of suppurative bacteria into the joints; third, those diseased joints produced by organisms which ordinarily produce not suppuration, but cause a proliferation of the tissue, such as the tubercle bacillus or syphilis; and, fourth, a great variety of causes which lead to long-continued irritation and injury of a low grade. Such injuries may be due to the deposit of urates or to the action of bacteria of very low grade, or to repeated traumatism, or to what may be called, for want of a better term, faulty metabolism. The changes produced in the joint will be taken up in the order just given.

I. **Traumatism of Joints Arising from Sprains, Contusion, Rupture of Ligaments, or Dislocation of Cartilage.**—These joints are characterized by an increase of fluid within the synovial sac, which causes swelling of the joint. There is an acute inflammation of more or less of the synovial membrane of the joint, which is red and injected, either in places or throughout. In the injured areas an inflammatory exudation is present. The increased amount of fluid is due to the presence of an inflammatory exudation which fills the joint, as extension of the exudate in that direction is along the line of least resistance. This exudation is in most cases a clear serous fluid in which a very small number of leukocytes may be present. In some cases there is an extensive formation of fibrin in the fluid, so that large coagula are formed, and solution and absorption of these masses of fibrin may take a long while and very much delay the process of repair and the resumption of function. In other cases, if the injury is very severe, there may be hemorrhage directly into the joint. In such cases the distention of the joint is extreme, the pain intense, and the formation of fibrinous coagula is practically a certainty. Thickening of the synovial membrane from edema is marked, and in some cases may be extreme, and may lead to thickening of the synovial membrane at the point of attachment to the cartilage. When repair takes place, the effusion may be entirely absorbed and the thickened synovial membrane may resume its normal condition. The fibrinous coagula may be softened and absorbed, or may slowly become organized, or, in certain cases, form the basis of "joint mice." In extreme cases the injured synovial membrane is thickened from the formation of granulation tissue in inflamed areas, and may lead to more or less destruction of the joint cavity or to actual adhesion or obliteration of portions of the joint.

II. **Suppurative Infection of the Joints.**—In some cases, either from laceration of a joint or puncture by an infected foreign body or as a result of surgical incision, or sometimes from entrance of pyogenic bacteria into the joint from suppurative foci in adjacent or distant parts of the body, and most commonly by direct extension from suppurative foci in the ends of the bones adjacent to the joint, the joint cavities become infected with pyogenic organisms. In those cases an acute purulent inflammation of the joint is produced. Moreover, the joint rapidly is filled with a purulent fluid, varying in color from yellow to green, in which leukocytes enormously predominate, *i. e.*, the joint is filled with pus. The synovial membrane is thickened and so injected that it often is a dark, purplish-red color. The thickening of the synovial membrane may become extreme, and the joint cavity may become enormously distended, because in most cases the capsule of the joint is so thick as to lead to great distention before the perforation of the capsule takes place, with an escape of the pus into the adjacent soft parts. Ligaments may be softened or destroyed and lead to partial or complete luxation of the ends of the bones. Ultimately the joint cartilage itself becomes edematous and soft, and small areas of erosion and ulceration appear. Such cases are usually fatal unless the joint is opened by the surgeon. In case, however, the joint abscess is artificially drained, the infection may cease and repair take place. In such cases there is usually an extensive destruction of the synovial membrane of the joint cavity, the synovial membrane is largely replaced by granulation tissue, and as repair goes on, adjacent granulation surfaces become more or less adherent, and partial or complete obliteration of the joint cavity may result. So, as a rule, the function of the joint once affected by suppurative process is enormously crippled.

III. **Tuberculous Infection of the Joints.**—Tuberculosis of the joints is almost always secondary to tuberculous infection of the epiphysis of one or more of the bones which form the affected joint. The identity of the lesions in the affected joints with that of other tuberculous lesions is generally accepted, but it may be worth while to state the method by which this identity has been established. The miliary tubercles seen in the joint lesions are the same miliary tubercles seen in other lesions known to be due to the presence of tubercle bacilli. Susceptible animals inoculated with bone or with soft tissue from affected joints, or with the wall of a cold abscess about such joints, or with pus from the cold abscess, die from miliary tuberculosis. Many experimenters have succeeded in producing in animals joint lesions similar to human tuberculous joints by inoculating animals with tubercle bacilli after having produced injuries of moderate severity on their joints. These facts are of great clinical importance. In cases of tuberculous lesions it is always possible to confirm the diagnosis by inoculating guinea-pigs with bits of tissue from the affected joints. Certain causes predispose to the occurrence of tuberculosis of joints. Such joint lesions are more common in early youth, and often are preceded by traumatism of moderate severity. The frequent coincidence of such injuries and tuberculosis of the joints makes it extremely probable that injury favors the occurrence of the disease. Tuberculosis of the joints is very rarely the primary tuberculous foci in the body, and tuberculosis of the joints

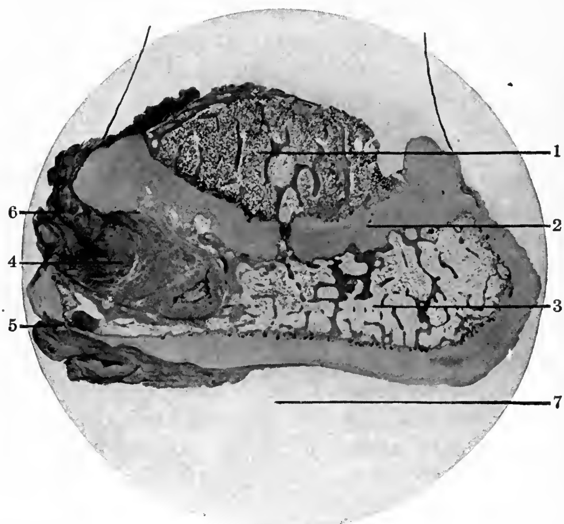


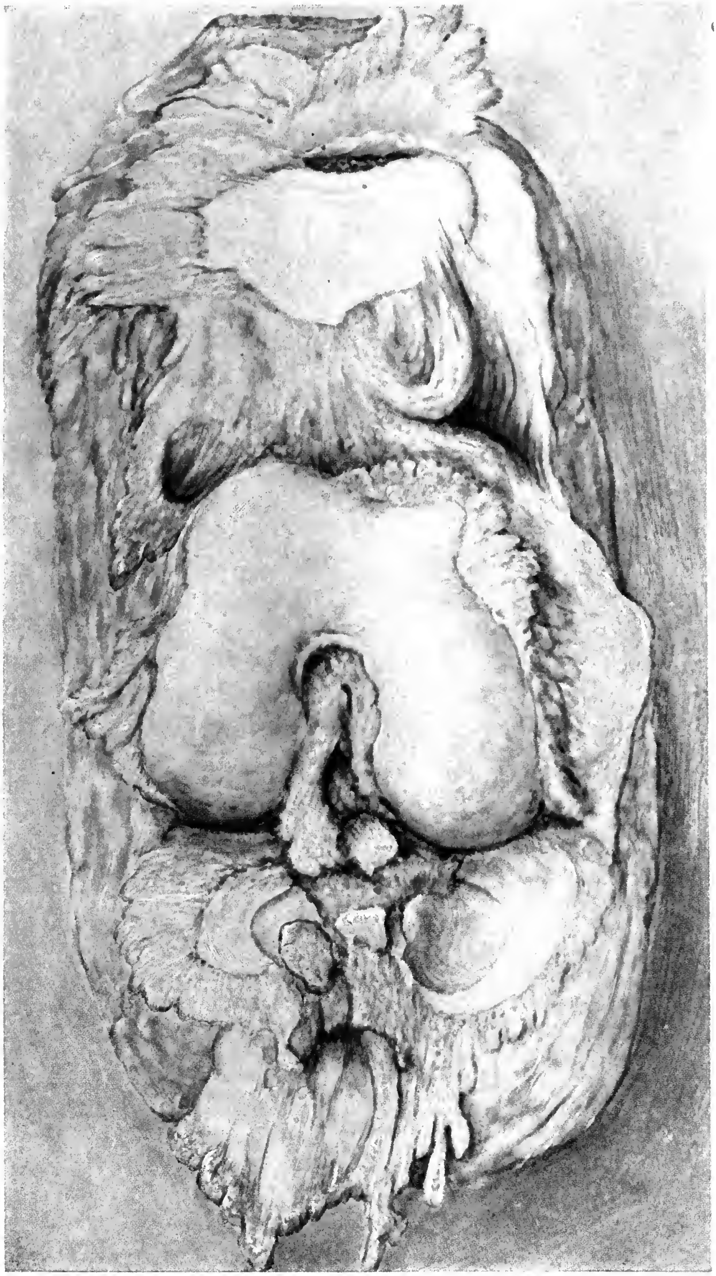
FIG. 220.—VERTICAL SECTION THROUGH THE DIAPHYSIS, EPIPHYSEAL LINE, AND EPIPHYSIS OF THE UPPER END OF THE RADIUS. FROM A CASE OF TUBERCULOSIS OF THE RADIUS.

1, Diaphysis, normal marrow, and trabeculæ; 2, epiphyseal line; 3, epiphysis; 4, tuberculous focus in epiphysis; 5, perforation of joint cartilage from the side of the bone; 6, perforation of the epiphysis at the point of attachment of the capsule; 7, joint cavity.

is almost always secondary to other tuberculous lesions elsewhere in the body, such as bronchial or mesenteric lymph nodes.

The tubercle bacillus having obtained access to the bone-marrow of the epiphysis, causes the formation of miliary tubercles. The adjacent tubercles enlarge, become caseous in the center, and, by fusion of the caseous areas, an area of softening is produced in the bone-marrow. The process always begins in the marrow, and at first leads to a destruction of the marrow and later to a softening of the trabeculæ of the bone. The process extends peripherally, and ultimately approaches the joint cartilage, and then extends into the joint cavity, either by erosion of the joint cartilage or, more commonly, by extension into the joint along the attachment of ligaments. The tubercle bacilli are set free in the

PLATE III.



Tuberculosis of the Knee-joint, Early Stage.

There is no ulceration of the synovial membrane nor of the joint cartilage. In places tuberculous pannus has extended over the cartilage. Numerous isolated tubercles are seen throughout the synovial membrane. This case *simulates* primary tuberculous synovitis, although there was an extensive primary bone focus in the epiphysis of the femur.

joint, and are diffused throughout the synovial fluid by movement of the joint. They are then taken up by the lymphatic vessels of the synovial membrane, and lead to the formation of miliary tubercles in various parts of the synovial membrane. These secondarily formed synovial tubercles also enlarge, caseate, and fuse, and in that way the surface of the synovial membrane becomes covered with tuberculous ulcers, which may lead to a partial or complete destruction of the synovial membrane. A layer of tuberculous granulation tissue, the so-called "tuberculous pannus," may extend from the edge of the synovial membrane over and beneath the joint cartilage. Wherever the cartilage comes in contact with this tuberculous pannus it becomes fibrillated, softened, and ultimately is destroyed. As a result the cartilage may be perforated at various points by ulceration either from the side of the joint or from below, thus giving rise to the "pepper-pot" cartilage, or the entire joint cartilage may be destroyed or may be lifted up from the underlying bone. The bone underlying the destroyed articular cartilage may also become secondarily involved in the tuberculous softening, so that destruction of all of the bones entering into the joint may be extensive, part of the destruction being that caused by the primary focus working from the bone toward the joint cavity, the secondary destruction being due to the extension from the joint cavity to the other bones which enter into the articulation. The process also may extend to and destroy all the ligaments which enter into the joint. As a result of these processes the synovial membrane, the articular cartilage, and the articular ends of the bones

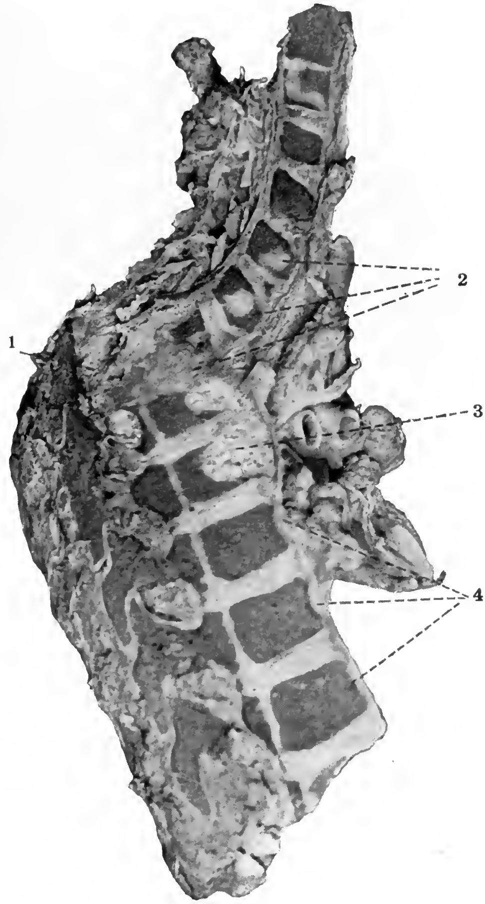


Fig. 221.—Vertical Section through Bodies of Cervical and Upper Dorsal Vertebræ.

1, "Knuckle"; 2, areas of tuberculous softening in bodies of vertebræ; 3, primary focus; 4, tuberculous masses extending beneath anterior spinal ligaments to infect adjacent vertebræ.

are destroyed, and consequently partial or complete dislocation may occur. The joint cavity contains a fluid composed partly of serum, partly of synovial fluid, and partly of caseous material derived from the coalescence and destruction of the tubercles.

In addition to this destructive tuberculous process there is always a new formation of granulation tissue about the tuberculous area, which is the result of an attempt of nature to wall off the destructive process. This leads to a marked thickening of the capsule of the joint. If an extension of the tuberculous process into the surrounding soft tissue occurs, by formation and coalescence of tubercles in these soft tissues an abscess cavity filled with caseous material and serum, lined with tuberculous tissue, and surrounded by a layer of reactive granulation tissue is formed—the so-called "cold abscess." As a rule, however, the cold abscess is due to the extension of the tuberculous process directly through the cortex of the bone, rather than to the extension through the capsule of the joint.

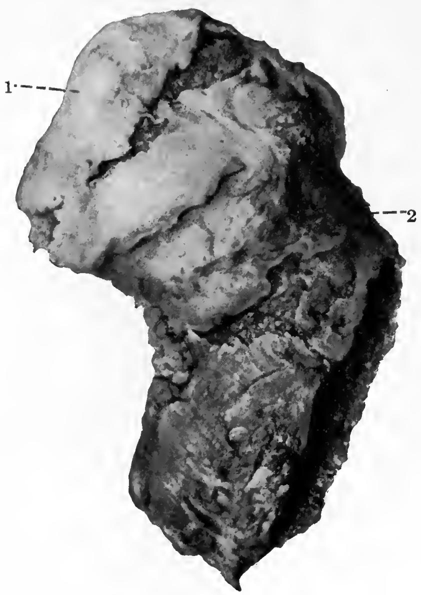


FIG. 222.—HEAD OF TUBERCULOUS FEMUR. ORIGINAL FOCUS IN THE ACETABULUM.
1, Joint cartilage, which has been elevated from underlying bone, and is perforated in various places—"pepper-pot" cartilage; 2, neck of femur.

It is said that occasionally solitary masses of tubercles occur in the joint, forming firm circumscribed nodules which show little tendency to caseate, but such a condition is extraordinarily rare. Sometimes in tuberculous joints, especially in the serous or dry form, there are found spheric or ovoid bodies, smooth, shining, opaque, and grayish—the so-called "rice bodies." They may be free in the joint or they are pedunculated. They may consist of concentric layers of fibrin, or are composed of vascular connective tissue. These "rice bodies" are not characteristic of tuberculous lesions, for they may be seen in various chronic joint affections which are not of tuberculous origin.

There has been a good deal of discussion as to the comparative frequency of the occurrence of the so-called "primary tuberculous synovitis." Some, chiefly surgeons, claim that primary tuberculous synovitis is relatively common as compared with the tuberculous joint lesions which arise secondarily to a tuberculous focus in the epiphysis. As a matter of fact, a general miliary tuberculosis of the synovial membrane without a primary focus in the epiphysis is extremely uncommon. An appearance *simulating* such a condition is not infrequent, and at the time of operation it may be impossible to say whether one is dealing with synovitis secondary to bone infection or with a primary tuberculous synovitis, but in nearly all cases where the joint can be examined postmortem or after amputation a primary focus in an adjacent epiphysis will be seen to be the primary cause of the joint affection. It might be supposed that since the use of the x-ray in joint diseases has become common that it would be possible to determine in all cases whether or not a primary focus was present, but this is not the case, because there may be an extensive bone focus with an extensive infection of the entire synovial membrane long before the bone focus has caused a sufficient destruction of the lime-containing trabeculæ of the adjacent epiphysis to make this lesion apparent on x-ray examination. This point is of much clinical importance, because in operations upon tuberculous joints it should always be the aim of the operator to remove not only the obviously tuberculous lining of the joint, but also the original focus in the epiphysis. Theoretically, the ideal treatment for early joint diseases would be to recognize by the x-ray the existing primary epiphyseal focus and to remove it before it had extended into and infected the joint. With more perfect development of the x-ray technic and with extension of a more accurate knowledge of the pathology of the joints, such ideal treatment may become as possible as it is desirable, but at present the difficulty is that the extension into the joint ordinarily has taken place long before the x-ray gives an accurate indication of the presence of the original bone focus.

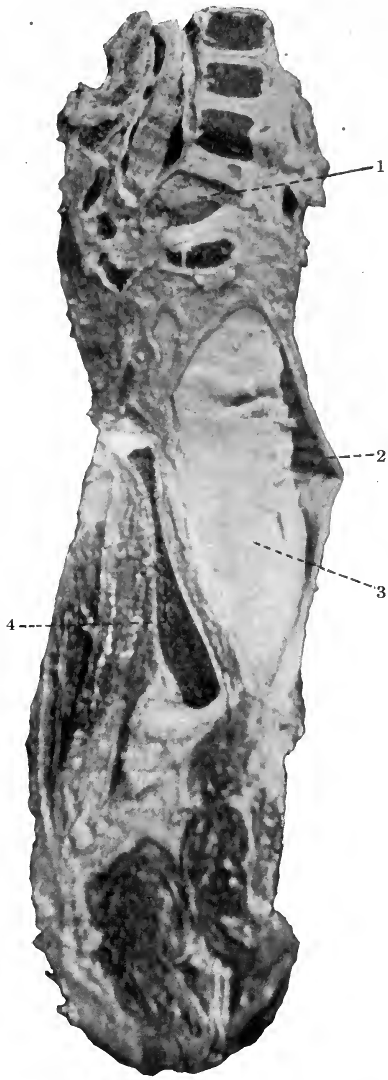


Fig. 223.—Oblique Section through the lumbar Vertebræ and Pelvis along the Iliopsoas Muscle.

1, Lumbar vertebræ with area of tuberculous softening in bodies; 2, peritoneal covering over cold abscess; 3, cold abscess (psoas abscess); 4, ilium.

Repair.—Tuberculosis, fortunately, is in most cases a self-limited disease, and if in tuberculous joint lesions the destructive process ceases to be active, repair may occur. Repair is brought about by a formation of granulation tissue which arises from the reactive granulation tissue surrounding all tuberculous areas, and either encapsulates or grows into and absorbs the tuberculous lesions. The caseous contents of a joint may be absorbed and the inspissated remainder may be replaced by fibrinous tissue, or may be calcified and encapsulated by fibrinous tissue. The adjacent partly destroyed joint surfaces may be firmly bound together by bands of fibrous tissue, with consequent diminution in the size of the joint and corresponding limitation of motion—the so-called "fibrous ankylosis." Or the adjacent bone surfaces may be bound together by such fibrous tissue, which may be converted either into cartilage or into bone, thus causing cartilaginous or bony ankylosis. Usually the ankylosis of adjacent bones is a mixture of these three forms of ankylosis. The joint cavity may be greatly diminished in size, or may be practically entirely obliterated. Unfortunately, however, even when comparatively complete repair takes place, certain small tuberculous areas may be inclosed in the granulation tissue. In such cases the joint may for a long while remain quiescent, but if any special injury or traumatism renews the activity of the tuberculous process, the ankylosed joint may be reinfected, with a corresponding recurrence of symptoms.

The process as just described is the process as it occurs in all the joints, but certain articulations require some special discussion because of their anatomic structure.

In the **hip-joint** the process begins sometimes in the upper epiphysis of the femur, and then the tendency is for the process to extend into the hip-joint and erode and destroy the head of the femur. The acetabulum becomes softened, and under the pressure of the head of the femur may be extended upward so that a partial subluxation of the joint occurs—the so-called "wandering acetabulum." Extension of the tuberculous process to the soft tissue, with the formation of a cold abscess outside of the joint, is common. In many cases, however, the base of the acetabulum is the site of the original bone focus, and in that case the process may extend not only into the joint cavity, but also into the inside of the pelvis, thus forming a tuberculous abscess in the pelvis outside the peritoneal cavity. Such an abscess may penetrate into any of the hollow viscera of the body, so that, as a rule, if the primary focus is in the acetabulum, the destruction of the joint is much more extensive, the secondary lesions are more diverse, and the clinical situation is much more serious.

If the head of the femur is extensively destroyed, partial or complete dislocation of the head of the bone may occur. Occasionally the tuberculous process is so extensive that it leads to fracture of the neck of the femur. The characteristic deformity is due to the reflex contraction of certain muscles about the hip-joint.

In the **knee-joint** the tuberculous process may begin in any of the bones which enter into the articulation, even in the patella.

In joints like the *carpus* or the *tarsus*, where each individual bone which enters into the joint articulates with several smaller bones, one small bone primarily may be affected, but in such a case the tuberculous process extends very rapidly from the original focus into several adjacent joints, secondarily destroying all the bones connected with the articulation, and in that way in a very short while may lead to much more extensive destruction and necrosis than would be the case in larger joints.

To recognize the limits of the tuberculous process in tuberculous joints is clinically often extremely difficult, even when a large joint, such as the knee, is infiltrated with miliary tubercles. Without extensive ulceration the determination of the limits of the disease is comparatively simple, but if extensive ulceration has occurred, the process may be much more complicated, and it may be impossible, without careful histologic study, which, of course, is usually impossible during an operation, to determine with accuracy the limits of the disease. Fortunately, in tuberculous joints the removal of the greater part of the tuberculous material leads to so active a reparative process that a remnant of a moderate amount of tuberculous tissue may lead to no serious result.

IV. **Chronic Arthritis** (*the Chronic Non-tuberculous Arthropathies*).—Under this term is included a series of chronic degenerative changes of the joints which may occur in young or old people, which may be monarticular or may affect several or all of the joints of the body, which may lead to a greater or less impairment of function, more or less extensive destruction of the joints with deformity, and at times to great suffering. There have been repeated attempts to classify the series of changes described under this heading into definite diseases, the classification being based upon clinical symptoms and the *x*-ray appearance of the joints. At present no sharp classification based upon pathologic changes, however, can be made, because, although the series of changes to be described can be more or less roughly divided into five different anatomic types, those types do not correspond with any degree of accuracy with the different clinical pictures presented by the various types of non-tuberculous joint lesions. In the course of time, with more accurate knowledge of pathologic and *x*-ray distinctions and with a more certain knowledge of the etiology of these different anatomic lesions, it may be possible to divide this series of changes now described under the term of chronic arthritis into definite clinical diseases. In consideration of the very great lack of definite knowledge as to the origin of these joint lesions it is desirable, in many cases of non-tuberculous joint diseases, to be able to recognize the pathologic condition which is present and leave the question of clinical differentiation into definite diseases alone. This is true for the following reasons: *first, that any given cause may produce in the same patient any one or all of the five different anatomic types of chronic joint disease, and, second, any one of the five anatomic classes can be produced by any one of a great variety of irritants.*

At present it is claimed that a great many different factors may produce at one time or another certain anatomic types of joint diseases. Traumatism undoubtedly may act as a predisposing and in many cases as an active cause of different types of joint lesions. Such traumatism may be of an acute character, such as causes, for instance, chronic arthritis of the knee, which follows repeated football injuries, or the injury may be of moderate severity constantly repeated, which produces the enlargement of the joint seen in the hands of many old laboring men. Under this same heading come the changes in the joint which are often ascribed to exposure to cold. Infections of various types also undoubtedly in many cases act as the starting-point of various types of the anatomic lesions. The gonococcus undoubtedly in many cases produces in joints an original lesion which is the starting-point for a complete destruction of the infected joints. It is probably true that various other organisms which produce acute inflammation of a moderate degree of severity also may act as the starting-point for chronic joint diseases. It has been claimed that in many of these chronic joint diseases a specific organism can be found which is the causative factor, but in my own opinion the evidence of the existence of such a specific organism is not proved. At present the question must remain *sub judice*. The lesions produced by these organisms of moderate activity must not, however, be confused with the acute suppurative process produced in joints which become infected with definite pyogenic bacteria. Also certain changes in the joints may be produced by what may be described as faulty metabolism, *e. g.*, there may be a deposit of urates in the articular cartilage of the joints, and this deposition of urates may ultimately lead to a disintegration of the joint cartilage and a gradual destruction of the joint. In other cases where many of the joints of the body are affected simultaneously, it seems probable, although it is not at present possible to demonstrate the fact scientifically, that interference with the metabolism of the body may be the exciting cause of joint disease. It also is true that certain chronic degenerative changes in the joints may be produced by various diseases of the central nervous system, tabes dorsalis, etc.

In all these cases, no matter what the anatomic type of the joint lesion may be, it is probably true that in many cases the original change comes in the tissue of the articular cartilage of the joint. Cartilage has an extremely limited power of repair, and it is probable that in many cases the original injury is a fibrillation and ulceration of the articular cartilage due to any one of the above-mentioned causes, and this ulceration of the cartilage in turn leads to a secondary injury of the joint, and so the process continues in a vicious circle of injury and erosion, erosion and injury, so that an injury of moderate severity may ultimately lead to very extensive destruction of the joint. In other cases it is undoubtedly true that the original change in the joint occurs in the synovial membrane, and that the destruction of the cartilage is secondary to the injury of the synovial membrane.

The anatomic lesions of the joints, as has been stated, can practically be divided into five different types—the serous, ulcerative, ankylosing, formative, and the fungous varieties.

PLATE IV.

Chronic Arthritis.

Ankylosing type. Left knee-joint flexed with integument turned back and joint opened by a crucial incision. Shows the upper end of the tibia covered with fibrous bands, the semilunar cartilages have disappeared. The joint-cavity is almost obliterated and tibia and femur are bound together by dense fibrous bands. The cartilage of the lower end of the femur has largely disappeared.

1. **Serous Type.**—In this type of chronic arthritis the chief change is an increase in the amount of synovial fluid in the joint cavity, sometimes with no other obvious change. Such joints may appear spontaneously or may be the result of one or of several injuries of considerable severity, or they may be dependent upon the presence of joint mice or of an overgrowth of the synovial membrane in the joint. They are characterized by an increase in the amount of fluid in the joint cavity.

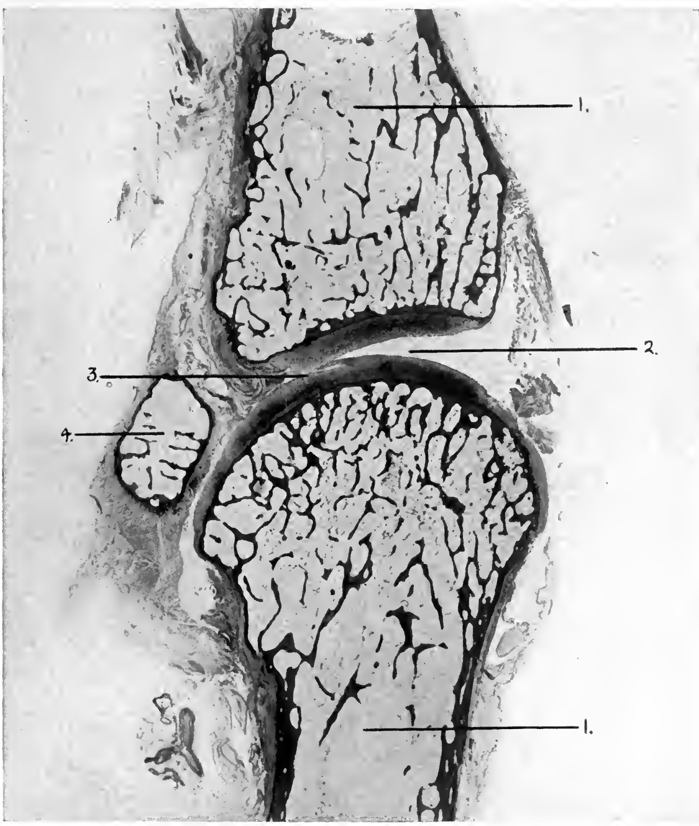


Fig. 224.—Ulcerative Type of Chronic Arthritis.

Microphotograph of vertical section through phalanges of thumb: 1, 1, Shaft of phalanges; 2, joint cavity; 3, early fibrillation of joint cartilage; 4, sesamoid bone.

The fluid may be of normal consistency or thinner or thicker. The joint ordinarily is very much distended. The capsule may be thickened or may appear normal, and the synovial membrane may or may not show any appreciable change. Such changes may affect only one joint, generally one of large size, the knee being the most commonly affected.

2. **Ulcerative type,** characterized by ulceration and destruction of

a greater or less extent of the joint cartilage, with or without marked changes in the synovial membrane. Various causes may lead to the production of such changes in the joint, such as the deposit of urates in gout, infection by the gonococcus, infection by other organisms of a mild type, by old age, or by diseases of the central nervous system. The process may affect one or many joints of the body. The process may continue as a pure ulceration of the joint cartilage, or it may develop into any one of the types about to be described. In such a joint the primary change usually consists in fibrillation and softening of the joint cartilage, which, under pressure, becomes eroded, and then the destructive process is continued by the vicious circle already mentioned. As a result of the erosion of the cartilage larger or smaller areas of the

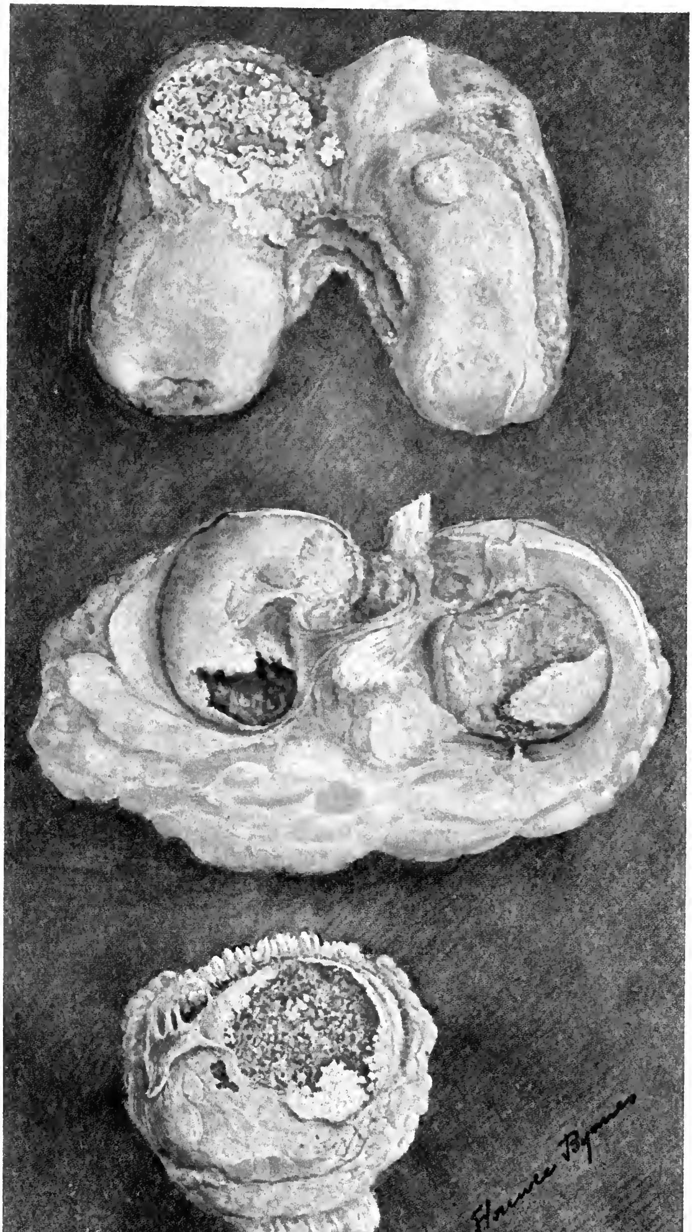
FIG. 225.—ANKYLOSING TYPE OF CHRONIC ARTHRITIS.

Microphotograph of vertical section through phalanges of fingers: 1, 1, Shafts of phalanges; 2, partly obliterated joint cavity; 3, 3, fibrous tissue uniting adjacent cartilaginous surface (fibrous ankylosing).

articulation are deprived of their cartilage, the underlying bone is laid bare, and, if the process continues, the bone may become thickened and eburnated, or its surface may be covered with a thin layer of granulation tissue derived from the connective tissue of the opened marrow-spaces.

3. **Ankylosing Type.**—Joint lesions of this type are always associated with ulceration of the joint cartilage. The primary change in such cases may be due to original ulceration of the cartilage or may be due to primary changes in the synovial membrane, which leads to extensive formation of granulation tissue, which, arising from the synovial membrane, extends over the joint cartilage and causes a secondary destruction of the cartilage. In either event there arises from the edge of the synovial membrane where it is attached to the cartilage a growth

PLATE V.



CHRONIC ARTHRITIS.

Ulcerative, ankylosing, and formative type in right knee-joint. Upper figure is lower end of femur, middle is upper end of tibia, and lower is patella. Femur shows thinning of entire joint cartilage with one small, rounded, thickened mass on internal condyle. On external condyle is an irregular area which articulated with the patella, to which it was joined by bony ankylosis. The upper end of the tibia shows ulceration of the articular cartilage. The patella shows that the articular cartilage has been replaced by bony ankylosis with the femur. Along the upper margins are newly formed spicules of bone.

of granulation tissue, the "synovial pannus," which extends over the surface of the joint cartilage. Wherever this pannus comes in contact with the joint cartilage, the cartilage becomes fibrillated, softened, and destroyed. This destruction of the joint cartilage may be partial or complete, but wherever adjacent articular surfaces are covered by this pannus, the two surfaces tend to become bound together by granulation tissue, which is ultimately converted into dense fibrous tissue. As a result, the ends of the bones are firmly bound together by bands of

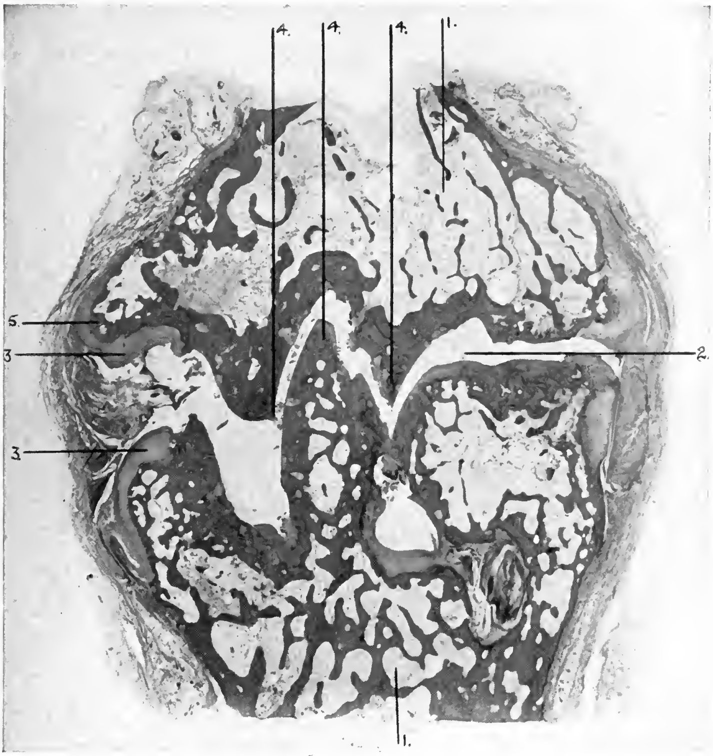


Fig. 226.—Formative Type of Chronic Arthritis.

Microphotograph of vertical section through adjacent phalanges of fingers 1, 1, Shafts of phalanges; 2, joint cavity; 3, 3, remnants of joint cartilage; 4, 4, 4, newly formed bone on exposed articular surfaces, producing great irregularity of joint and "ankylosing from deformity"; note that bony articular surfaces are dense and thickened (eburnated bone); 5, new formation of bone at periphery of joint ("Heberden's nodes").

fibrous tissue which, to a greater or less extent, may obliterate the joint cavity. In some cases there may be a transformation of this fibrous tissue into cartilage, giving rise to cartilaginous ankylosis, or there may be a transformation into bone. In some few cases the destruction of the articular cartilage and the formation of bony ankylosis is so complete as entirely to destroy the surface of the articulation and to unite two adjacent bones by one continuous narrow canal.

4. **Formative Type.**—This type of chronic arthritis also always

develops in connection with ulceration of the joint cartilage, and also is characterized by a new formation of bone at the margin of the joint and beneath the ulcerated cartilage. The new bone at the edge of the joint arises from the periosteum; the new bone beneath the cartilage arises from the thickened endosteum lining the exposed bone-spaces. This type of lesion is much more common in old people, especially in women, than in the young. Certain joints are commonly affected, notably

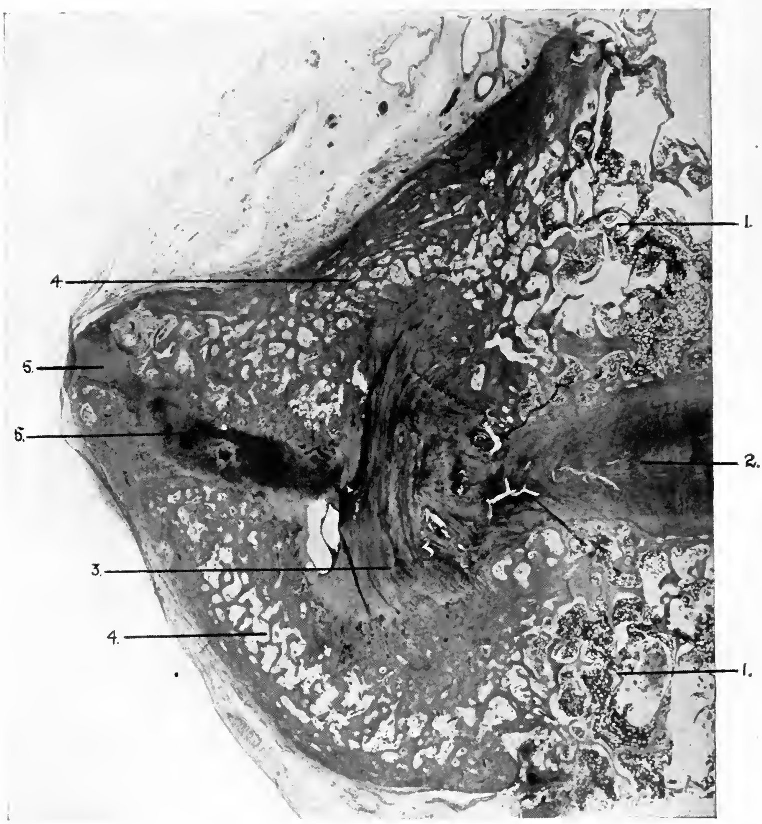
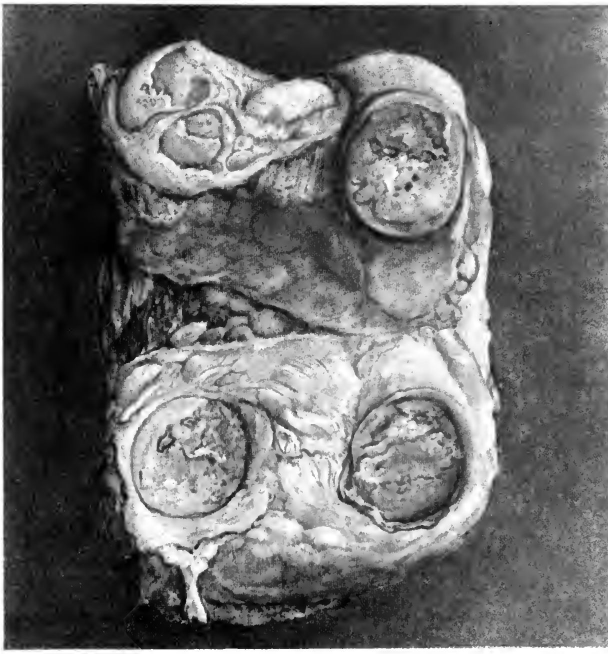


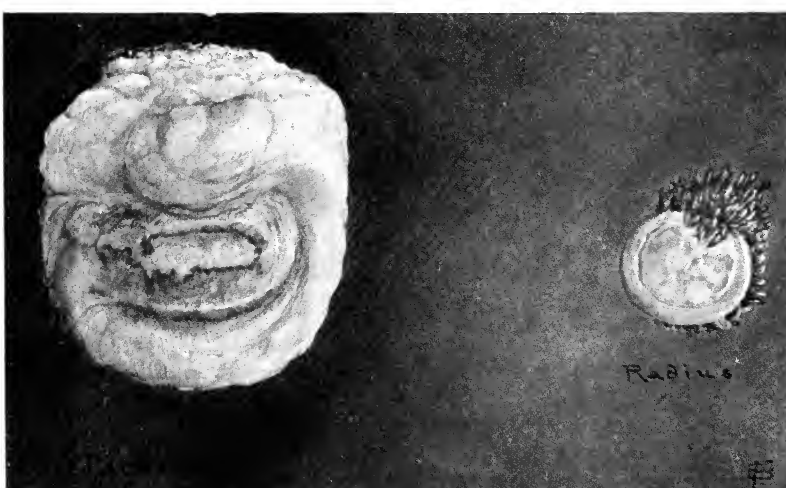
FIG. 226 a.—FORMATIVE TYPE OF CHRONIC ARTHRITIS.

Microphotograph of vertical section through the bodies and intervertebral disk of two adjacent vertebræ: 1, 1, Original bodies of vertebræ; 2, intervertebral disk; 3, remnant of anterior ligament; 4, newly formed bone, arising from the anterior surfaces of the vertebræ; 5, newly formed intervertebral disk.

the fingers, the hip, and the spine. In certain cases these changes give rise to distinct clinical types of lesions, *e. g.*, malum coxæ senile, spondylitis deformans. These joints are characterized by ulceration of the cartilage over certain parts of the joints, with an overgrowth or hypertrophy of the cartilage in other parts. As a result, the joint cartilage becomes irregular and dentate. There also is always a new formation of periosteal bone at the periphery of the joint, and beneath the ulcerated

PLATE VI.





CHRONIC ARTHRITIS.

Upper figure is right knee-joint. Lower figure, left side, is pate la from same knee. Right side is head of the radius, seen from the end. The knee-joint shows extreme ulceration of cartilage throughout the entire joint. The patella also shows ulceration of cartilage. The radius shows villous thickening of the synovial membrane.

areas and in the elevated portions of the joint cartilage. These bony trabeculæ thicken, and ultimately there ensues very great irregularity of the joint surfaces, with great impairment of function, due partly to the irregularity of the articular surfaces and partly to the presence of masses of new bone at the periphery of the joint.

The appearance in different joints may be characteristic. In the spine a condition called spondylitis deformans occurs. The entire vertebral column may become extremely rigid, due to the presence of

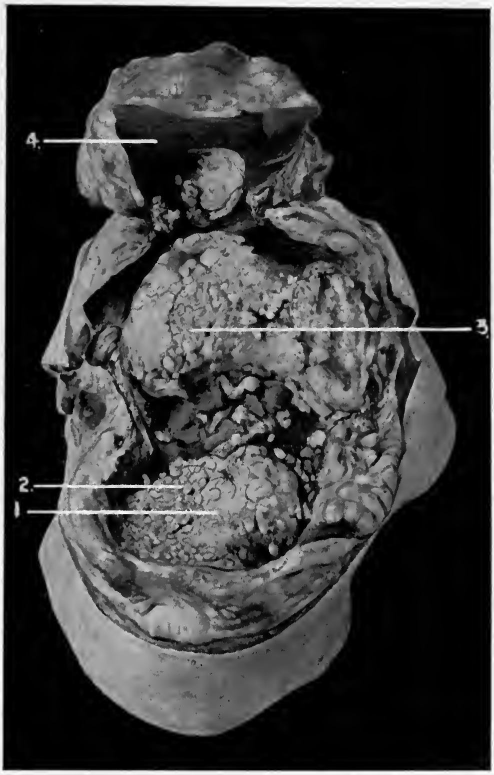


Fig. 227.—Knee-joint from Patient with Syphilis, Tabes Dorsalis, and Charcot's Joint. Joint cavity is laid open by transverse and vertical incisions: 1, Irregular head of tibia; 2, fungous mass nearly filling the joint cavity; 3, lower end of femur; 4, patella turned upward.

masses of periosteal bone which grows out underneath the ligaments and form large bosses or buttresses which mechanically prevent flexion of the spine, or, in other cases, buttresses arising from adjacent vertebræ may fuse together into one solid bony mass and in that way lead to ankylosis of adjacent vertebræ.

In the hip-joint (malum coxæ senile) the erosion of the head of the femur may be very great, while the new formation of bone at the edge of the articular cartilage of the hip also may be extreme. As a result, the head may be diminished in size or markedly altered, so as to present a mushroom-like appearance, while at the same time the acetabulum may be partly eroded and partly filled up by masses of newly formed bone, so that, just as in certain types of tuberculous hip diseases, a wandering acetabulum may result.

This series of changes may lead to the characteristic appearance of the fingers seen especially in old women, giving rise to the clinical appearance known as "Heberden's nodes." Any joint of the body, however, may be affected by changes of this type.

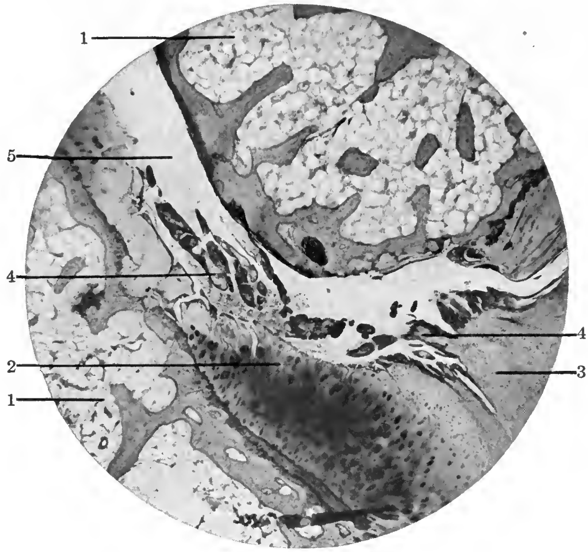


Fig. 228.—Fungous Type of Chronic Arthritis.

Microphotograph of vertical section through shafts of adjacent phalanges: 1, 1, Shafts of phalanges; 2, fibrillated joint cartilage; 3, capsule of the joint; 4, fungous growth projecting into joint cavity; 5, joint cavity.

5. **Fungous or Villous Type.**—In this type of chronic joint changes there is a marked overgrowth of the synovial membrane. Masses and tags of papillary overgrowths of the synovial membrane project into the joint. These tags may be composed of granulation tissue with a central blood-vessel, or the tags may be formed either of cartilage or of bone. These tags of cartilaginous or bony masses may be pinched off and left free in the joint cavity. In this way most commonly are formed the free bodies commonly seen in the joints as "joint mice."

SURGERY OF THE JOINTS: CLINICAL PART.

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In taking up the consideration of the surgery of the joints it must be assumed that the surgeon is familiar with the general characteristics of the gross and microscopic anatomy of the articulations.

The examination of joints is intended to determine two points: (1) Whether the joint is abnormal or not; (2) what is the character of the abnormality, *e. g.*, is it tuberculous, traumatic, infectious, or hysteric, and is the swelling in the joint or outside of it, etc. Any examination based on the diseased joint alone, without an investigation of the healthy one on the opposite side, is imperfect.

The following covers the points to be observed in such an examination:

Inspection.—**Swelling** is often evident in the more superficial joints, but absent in the deep-seated ones.

Abnormality of position is frequently evident on inspection.

Impairment of function can frequently be eliminated by watching unconscious movements better than by manipulation.

Palpation.—This furnishes, on the whole, the bulk of the required information.

Swelling is easily detected in superficial joints, such as the knee, but is found only with care in deep joints, like the hip, and is not to be found in the vertebral joints. It should be determined whether it appears to be mostly in the articular, peri-articular, or bony tissues; and whether it is fluctuating, boggy, or dense.

Increase in the circumference of the joint, as shown by a tape-measure, is evidence of swelling in or about the joint. The absence of such increase is not evidence that swelling is not present.

Heat.—In superficial joints heat may be detected by the hand or skin thermometer, if present. In deep joints it cannot be detected even if present. It must be remembered that a heavily bandaged joint at first appears warmer on account of the retained heat.

Redness is at times present in superficial joints in cases of acute inflammation, but absent in the case of deeper joints, unless an abscess is pointing.

Muscular Atrophy.—Wasting of the muscles about the affected joint begins very soon after the beginning of the affection. It should be established by the measurement of the affected limb above and below the joint, as compared with the unaffected member. The levels of measurement must be established on both sides by measuring the same distance up and down from some bony landmark, marking the skin and taking the circumference of the limb with a tape-measure. The limbs, of course, should be placed in corresponding positions for the measurements.

The two remaining symptoms are subjective, while the previous ones are objective.

Tenderness.—Sensitiveness is most marked where the synovial membrane is most superficial, especially if it lies over a bony surface.

Limitation of Function.—This is to be detected by a diminution of the normal arc of motion of the affected joint. It is essential, first, to examine the joint of the unaffected side in order to secure a standard of comparison and to accustom the patient to the manipulation. The restriction may be—(1) Voluntary, in which case it is caused by the pain of motion, by fright, in the case of malingering, or by the unconscious deception of a hysteric patient. (2) It may be involuntary, in which case it is caused by ankylosis or by tonic muscular contraction (muscular spasm). Examination should distinguish between voluntary and involuntary restriction, which is done by distracting the patient's attention during manipulation, watching the natural movements, and noting the constancy of the restriction, which varies in voluntary restriction and not in involuntary.

Examination under anesthesia is chiefly useful to distinguish between the loss of motion due to ankylosis and that due to muscular restriction, as the tonic spasm of joint disease disappears under full anesthetization.

Auscultation.—By means of a stethoscope placed over the joint, which is then gently moved, the presence of slight degrees of creaking may be detected.

x-Ray.—The radiograph is, in most cases, a necessary part of a complete examination and a radiograph of the corresponding normal joint is often useful. Fluoroscopic examination is of no value, and poor radiographs are of slight use. Bone outline and bone density should be clearly shown, including the absorption of lime salts incident to joint disease and any diminution in the size of the bone. The highest grade of picture may be expected to show under favorable conditions the outline of the joint capsule, the contour of some of the muscles and tendons, and the shadows of intra-articular cartilages in the knee.

For the better development of the *x*-ray a method has been described of distending the joints by the injection of oxygen before taking the radiograph, thus expanding the synovial sac and making clearer the contour of its inner surface. The joint cavity appears in the picture as an area clear of shadows bordered by the synovial surface of the joint-sac, on which inequalities, hypertrophied fringes, and thickening are clearly evident. The method has hardly passed beyond the experimental stage.[55]

Aspiration.—The withdrawal of the fluid contents of the joint for microscopic examination or for inoculation is at times desirable.

History.—It should be said, by way of comment, that the history, especially in the case of joint disease in children, is frequently misleading, and that the best information is to be obtained from the physical examination. The tendency of the parents to attribute chronic joint disease to trauma rather than to heredity, the disposition to overlook the insidious early history, and the suppression of discreditable personal histories form constant obstacles.

ACUTE SYNOVITIS.

Acute synovitis is usually either of traumatic or infectious origin. Synovitis of infectious origin will be discussed under Infective Arthritis.

Symptoms of Acute Traumatic Synovitis.—Immediately upon receipt of an injury or after a few hours the affected joint feels to the patient hot and stiff—often as if it were filled with hot sand. Certain movements are uncomfortable, and the muscles may feel shortened.

Malposition.—Pain may be present and be increased by motion. Certain definite positions, more or less peculiar to each joint, are, as a rule, adopted. The hip is flexed and adducted, the knee flexed, the ankle plantar flexed, while the positions of the arm-joints are less characteristic.

Swelling due to an excess of synovial fluid develops and distends the synovial sac and capsule, and outside of the joint proper there is some thickening of the peri-articular structures. Fluctuation is to be obtained over the distended joint-sac generally in the elbow and shoulder, rarely in the wrist or ankle, and only exceptionally at the anterior surface of the hip. At the knee the patella is lifted away from the femur even by moderate distention: and when the leg is fully extended and the upper and lower parts of the joint-sac are compressed by encircling with the hands the anterior surface of the limb above and below the patella, the patella can be depressed by a sharp pressure of the finger and felt to descend through the fluid and strike against the bone. This phenomenon is called "floating of the patella."

Heat is present in a slight degree, and *tenderness* is almost universally to be found, while *redness* is rarely to be seen. *Impairment of function* exists largely as a result of the pain caused by use, from the distention of the joint-sac, and from a slight loss of power in the muscles occurring early in the history of acute synovitis.[4] *Muscular atrophy*[4] is a constant and early symptom in this as in all affections of the joints.

The synovitis is generally from one to three days in reaching its maximum, at which time it becomes stationary, the swelling then becoming the most marked symptom and remaining so to the end, the tenderness, heat, and acute symptoms diminishing after the onset.

The last signs to disappear are the swelling of the synovial membrane, the muscular wasting, and an irritability of the joint under overuse.

Diagnosis.—The diagnosis of traumatic synovitis rests on the presence of effusion in the joint following trauma. Local tenderness, restriction of motion, muscular atrophy, and generally pain or discomfort are accompanying symptoms. The history must often be relied on to distinguish traumatic synovitis from that of infectious origin.

Differential Diagnosis.—Traumatic synovitis must be differentiated from—(1) Peri-articular injury. (2) Bursitis in the neighborhood of the joints. (3) Joint tuberculosis is frequently diagnosticated as acute traumatic synovitis, especially in hospital patients, where a joint disease has been overlooked until attention has been called to it by a trauma. (4) Fracture, the rupture of ligaments, and the rupture of muscles are always to be borne in mind in making a diagnosis of acute traumatic synovitis. An examination under anesthesia should be made in all doubtful cases.

Prognosis.—Acute traumatic synovitis in a healthy person under proper treatment should progress to complete recovery within from two to twelve weeks, provided there has been no anatomic injury to other joint structures.

The chief obstacles to complete recovery are—(1) the too early discontinuance of treatment and (2) conversely, too long continuance of treatment, which accentuates the muscular atrophy.

Treatment.—The most effective means at our disposal is rest to the joint by the use of a splint made of wood, tin, or plaster-of-Paris. In the shoulder, fixation is best obtained by strapping or bandaging the arm to the side. In the hip, a plaster-of-Paris spica bandage is applied, or the patient is put to bed on a bed-frame and traction is applied to the leg.

Fixation is continued until the fluid begins to subside, when measures to stimulate the local circulation are indicated. Massage, beginning in periods of fifteen minutes, given once or twice daily, is started as soon as the heat and extreme tenderness have disappeared, and continued until the synovial membrane is practically normal. If it irritates, it should be stopped. Hot-air baking is useful from the outset, and should be given for thirty to forty-five minutes once a day. Douching, sponging, or packing with hot water is useful from the beginning, and when the effusion has subsided, is more effective if followed by a cold douche.

Compression to the joint when possible is desirable by a flannel bandage firmly and evenly applied over the splint. At first the splint should be removed only for the local treatment mentioned and immediately reapplied. When the effusion has disappeared, restricted but gradually increasing use should be allowed the protected joint. Unrestricted use is permissible only after the synovial membrane has become apparently normal, and use of the joint is not accompanied or followed by any serious amount of pain.

Fixation must be continued long enough to quiet the inflammation of the joint, but not after that, for in the latter case muscular atrophy and a weak and irritable joint are favored. A second method of treatment by massage from the outset is described under sprains.

CHRONIC SYNOVITIS.

As our knowledge of joint disease increases we realize that chronic synovitis is more often secondary to some cause than a primary condition of itself. It is seen clinically—

1. As the result of incomplete recovery from acute synovitis.
2. As a sequel to acute synovitis due to muscular laxity.
3. As a manifestation of the existence in the joints of irritating causes, such as hypertrophied fringes and the like.
4. As a symptom of chronic joint disease due to some general cause, such as gonorrhea or arthritis deformans.
5. As an intermittent affection without known pathology.

1. **Chronic Serous Synovitis.**—In certain cases of the acute form the effusion persists, and with it some of the tenderness and irritability. Swelling is noticeable, but heat is absent as a rule, tenderness is not acute, and muscular atrophy is marked. The patient complains that the joint is weak and insecure, easily becomes irritable, and is somewhat painful after use. It improves and grows worse again after overdoing or some slight twist or wrench. The condition shows but little tendency to spontaneous recovery, and may have persisted for weeks or months.

2. The **muscular atrophy** and consequent weakness following joint inflammation may of itself constitute a source of joint irritability and a low grade of chronic synovitis. It is favored by prolonged fixation. Such joints tire easily and are irritable, while atrophy of the extensor muscles of the knee is marked.[57]

3. When it exists as the result of the irritation of **foreign bodies in the joint,** most often in the knee, the symptoms are characterized by sudden catches of the joint, most often in the flexed position, followed by an increase of fluid, pain, and disability. At other times a slipping is felt, more or less painful, followed by some reaction in the joint. As the condition becomes more chronic the slip or catch becomes less painful, and is followed by less reaction, while the joint remains in a worse average condition and the fluid is more constantly present. In the more marked cases lateral movement of the knee is possible to a slight degree.

FIG. 229.—INTERMITTENT SYNOVITIS, BOTH KNEES.

4. Chronic synovitis associated with **infections,** such as gonorrhea, or with abnormal general conditions, such as hemophilia and arthritis deformans, will be mentioned under those headings.

5. **Intermittent Chronic Synovitis.**—Intermittent hydrops is the name given to a serous effusion occurring at more or less regular intervals, most often attacking the knee. The periodicity of the attacks may be quite regular, and in the interval between attacks the joint seems to be normal. The effusion is not, as a rule, particularly painful, and the chief discomfort is from the distention and stiffness induced by it. The etiology is wholly obscure.[58]

A painless effusion is described as occurring in the knee-joints of women and girls during menstruation or in connection with uterine disorders.

The **prognosis** of chronic synovitis depends on the efficiency of treatment, the affection having but little tendency toward spontaneous recovery.

Treatment of Chronic Synovitis.—Simple chronic synovitis, which is merely the outcome of the acute condition, should be treated temporarily by fixation and compression if symptoms of irritability are present, in order to regulate the local circulation and diminish the effusion. Following this should come treatment by stimulating measures, which should be instituted as soon as effusion and irritability have diminished. These consist of massage, hot air, douches, and increasing and restricted use, as described in speaking of convalescence from acute traumatic synovitis.

If muscular atrophy to a marked degree is present, massage should be the chief factor in the treatment, along with active and passive exercises, douching, and vibration.

If chronic synovitis exists as the symptom of an intra-articular irritation from a foreign body and the like and proves resistant, the cause of the irritation must be removed. It is permissible to open the joint in resistant cases for the establishment of a definite diagnosis and the possible removal of existing sources of irritation.

Cases of chronic synovitis due to infections or abnormal general conditions will be discussed later.

No satisfactory treatment of chronic intermittent synovitis has been formulated.

INFECTIVE ARTHRITIS.

Inflammation of the joints may occur in connection with most of the general infections, but no one type of joint inflammation is necessarily connected constantly with any one infection. For example, scarlet fever may have as a complication an acute osteomyelitis involving the joint, a suppurative arthritis or abscess of the joint, or a simple serous synovitis.

Joint affections accompanying and presumably the result of infection fall, as a rule, into four types:

(*a*) Acute osteomyelitis of the articular end of the bone involving the joint secondarily. (*b*) Acute suppurative synovitis or arthritis (abscess of the joint). (*c*) Fibrinous or plastic synovitis or arthritis causing partial or total obliteration of the joint. (*d*) Acute serous synovitis.

Acute osteomyelitis is discussed in the chapter on the Bones.

Acute Suppurative Synovitis or Arthritis.—This may be the outcome of a serous synovitis or it may start without any obvious serous stage. When it follows a serous effusion, the symptoms of that affection increase, swelling and pain become more marked, redness becomes evident, the temperature generally rises, and aspiration shows a cloudy or purulent fluid, instead of a serous one.

When the affection occurs without an obvious serous stage, it is frequently ushered in by a chill, and inflammation of the joint of obvious severity is evident. Pain, swelling, great tenderness, and loss of motion are conspicuous symptoms, and the reddening of the skin is characteristic. The symptoms of sepsis and the high temperature make themselves evident early in the disease, and the infection of the general system is most marked.

The **diagnosis** may be easily made by the withdrawal of the fluid in the joint by a hypodermic syringe. In many cases this is not necessary, as it is evident without it.

In general, the **prognosis** is good as to life if treatment is undertaken early, but always doubtful as to function. In cases of general streptococcus infection the prognosis is not so good, and if more than one joint is involved, it is the prognosis of pyemia, depending on the severity of the infection.

The **treatment** consists in the freest possible incision of the joint and permanent drainage. The irrigation of the joint with sterile salt solution is of value. The knee offers more difficulty than does any other joint, on account of the extent of the synovial membrane and the pockets existing in it. Generally, two longitudinal incisions are sufficient, but in very severe cases, or where drainage is imperfect, a U-shaped incision should be made, beginning inside well above the patella, sweeping down below the patella, dividing its tendon, and passing up at the outer side of it. The patella is then turned up and the knee thoroughly exposed. The knee is then fixed in flexion, thus laying open the entire joint. Of course, it should be well enveloped in antiseptic dressings. Later the patellar tendon can be reunited by sutures.

Small incisions are bad surgery, and delay in operation has no excuse. The drainage of the joint should be discontinued as soon as it is safe, and gentle passive movement begun at the earliest practicable moment, but so long as acute symptoms are present, it is not likely to be of value.

Plastic or Fibrous or Ankylosing Arthritis.—In connection with certain infections, notably gonorrhea, an acute synovitis or arthritis begins which is manifested by pain, swelling, tenderness, malposition, and the other symptoms mentioned, but which does not go on to suppuration and terminates in an ankylosis, partial or complete. In such cases, although the local symptoms are generally very acute, the general sepsis is comparatively slight. The main character of the affection is a dense brawny swelling of the joint and peri-articular structures, and when the affection subsides, fibrous bands have been formed impairing very seriously the motion of the joint. It is essentially a joint disease of adult life, occurring rarely in children.

No satisfactory treatment for it has been formulated.

Acute Serous Synovitis.—As an accompaniment of infection, acute serous synovitis does not differ essentially in symptoms or treatment from the same affection occurring as the result of trauma, but is, on the whole, more painful and requires longer fixation.

The types of infective synovitis or arthritis seen most frequently in the various infections will now be considered.

Gonorrheal Arthritis (*Gonorrheal Rheumatism*).—The arthritis of gonorrhea occurs, as a rule, in the third week of the infection, but rarely may be seen earlier; and the liability to it exists theoretically so long as gonococci persist in the urethra. It is acute or chronic, and monarticular or more often polyarticular. It may occur in the vulvovaginitis of little girls, in gonorrheal ophthalmia of babies,[31] and after the passage of a sound into the urethra.

The joints are affected in the following order of frequency (Northrup, Finger, Benecke[30]):

Knee	258	Hip	42
Ankle	125	Temporomaxillary	16
Wrist	76	Small joints of foot	46
Elbow	53	Heel and toes	21
Shoulder	44	Small joints of hands	50
Other articulations	24		

The types of the affection are as follows:

(1) Arthralgia without definite lesions in the joint. (2) Acute serous synovitis with much peri-articular swelling. (3) Acute fibrinous or plastic synovitis with slight effusion. (4) Chronic serous or purulent synovitis. (5) Involvement of peri-articular structures, such as bursæ and tendon sheaths.

The affection generally begins insidiously, with pain and stiffness, and the temperature may be but little affected; rarely it begins acutely with an elevation of temperature. It most often resembles an attack of acute articular rheumatism of considerable severity, and pursues a very slow course after the acute stage is reached, thickening, tenderness, and stiffness of the joints persisting; marked sepsis is rare. It is essentially a multiform affection, with one general characteristic in practically all cases —its great persistency.

It is due to the presence of gonococci, which may not be found in the joint fluid, especially in chronic cases. These cocci may be present in the pus-cells of the granulation tissue or in the exudate. A mixed infection with pyogenic organisms may be found, or even pyogenic organisms alone.

The **diagnosis** will rest on the history and on the detection of gonococci in the urine or elsewhere.

Prognosis.—The prognosis as to life is good, but as to speedy and complete recovery very uncertain. Slight cases recover with perfect motion, but acute cases may suppurate, and some degree of ankylosis is common in all grades of cases.

Treatment.—In the acute stage the joint should be treated by fixation and protection. Hot-air baths are of use, and compression seems of value.

If suppuration occurs, the joint should be freely incised, irrigated, and drained.

If the affection pursues a slow and obstinate course, accessible joints, such as the knee, should be incised, flushed with hot sterile salt solution, and drained with strips of gauze. Severe cases should be flushed out daily for some days after being opened. Drainage is to be omitted and the incisions allowed to close, when the acuteness of the symptoms subsides, as it generally does under this treatment. In the deeper joints, such as the hip, where incision is not practicable generally, in cases of the multiple affections of joints, and in cases where, for other reasons, incision is not advisable, the ordinary measures in use in chronic synovitis, of protection and fixation along with massage, douches, and similar proceedings, are to be used.

Influenzal Arthritis.—Epidemic influenza may be the starting-point of joint infections[32] of rather a severe grade as a rule, the plastic or obliterating type of arthritis being apparently the commonest. In other cases the influenza seems to start a process that eventuates in arthritis deformans.[33] Influenza occurring in the course of chronic tuberculous joint disease may cause an exacerbation of the process by which it takes on a much more active type.

Pneumococcic Arthritis.—An arthritis, most often of suppurative type and of a very grave character, occurs at times in connection with pneumonia and as the result of pneumococcus infection from other sources. It is in general a late complication, but in some cases is said to precede the pneumonia.[42] In 31 cases collected by Cave,[34] suppuration occurred in 27, and of the whole number, 23 terminated fatally. Men are more often attacked than women, and it may occur in children.

The organisms, as a rule, exist free in the fluid or embedded in the larger cellular elements, and a thin layer of cocci exists on the surface of the synovial membrane, but the deeper layers of the tissues, as a rule, contain no organisms. In some cases where the coccus can be found in other parts of the body, it does not exist in the joint effusion.

Clinically the symptoms are severe, the temperature high, and the course rapid. The diagnosis is made from the recognition of pneumonia or of some other source of the infection and by bacteriologic examination of the joint fluid.

The **treatment** is the same as described in parallel conditions.

Typhoid Arthritis.—Nowhere is the multiform character of joint infection more clearly seen than in typhoid fever. Acute osteomyelitis involving the joints, suppurative arthritis, ankylosing or plastic arthritis, and serous synovitis all occur at times, the two former being the commonest forms. The affection is either monarticular or less frequently polyarticular, and occurs, as a rule, rather late in the history of the disease, but may be seen in the acute stages; exceptionally it is to be found in convalescence.

It does not differ essentially from similar types of arthritis seen in other septic conditions, but is more often overlooked at first on account of the apathy of the patient and the severity of the general disease.

In the joint-fluid the specific bacillus is sometimes found; at other times the joint-fluid is sterile, while in a third class of cases pyogenic organisms are present. Arthritis has been produced by the intra-articular injection of cultures of the typhoid bacillus.[44]

The polyarticular type of the joint affection is less serious than the monarticular, and is more likely to be a serous effusion. It apparently adds but little to the gravity of the prognosis, but may be followed by ankylosis.

The monarticular type, on the other hand, affects one of the larger joints, generally in young persons, most often the hip, and is a much more serious affair. The pain is usually slight, but may be severe, suppuration is rare, and swelling is marked. The attack may end in recovery or in ankylosis, but in more than one-half of the cases collected by Keen dislocation of the joint occurred (40 times in the hip, twice in the shoulder, and once in the knee). These dislocations are analogous to those observed in other infections, in locomotor ataxia and similar conditions. The mechanic cause of the dislocation of the hip is apparently to be found in the joint distention, which spends its force posteriorly, the Y ligament in front remaining tense and favoring spontaneous backward dislocation. Dislocations generally occur after the third week of the disease, and may or may not be accompanied by pain.

The dislocation should be reduced and held in place by a plaster-of-Paris spica bandage as soon as it is discovered. Should it, however, prove impossible, the deformity should be rectified by open incision if there is a head left on the femur. If ankylosis in vicious position has occurred, osteotomy should be performed to correct it. If a painful joint develops in typhoid, especially in the hip, great care should be taken to prevent dislocation, the limb being kept abducted and rotated outward, as the position most secure against displacement. This is best accomplished by a weight and pulley extension, or by a plaster-of-Paris spica bandage, according to the patient's condition. In other respects the treatment of typhoid arthritis does not differ from that already described.

Rheumatic Synovitis.—The affection known as "acute articular rheumatism" and "rheumatic fever" is an acute condition characterized by an inflammation of the joints accompanied by a serous effusion at times, and by inflammation in the heart and some of the serous membranes. Fever and sweating accompany the severer cases, and pain is generally present in all grades. This group of symptoms, familiar to every practitioner, has strong claims to be considered as an infectious disease. The joint manifestations do not differ essentially from those serous effusions seen in connection with scarlatina, typhoid fever, and similar general infections, except that they are more benignant and never suppurate.

It has been pointed out that there exist in the tonsils certain cocci resembling streptococci, which can excite "rheumatic" effusions, endocarditis, and chorea when injected into animals.[35] Here exists a ready source of entrance for pyogenic organisms, especially in connection with inflammation of the throat and tonsils. A case of joint infection of rheumatic type has been reported, apparently due to chronic appendicitis, and the cavities connecting with the nose are other sources of infection. No case, therefore, need be classed as non-infectious because of the absence of an obvious focus of infection.

Three organisms, micrococcus rheumaticus (Walker), diplococcus rheumaticus (Poynton), streptococcus and chorea (Wasserman), have been at times found in the joint effusion, the endocardium, and the tonsils in acute attacks of "rheumatism." Injected into animals, joint effusion, endocarditis, and chorea have resulted.[36] On the other hand, streptococci from various sources have produced synovitis and endocarditis when injected into animals.[37] It cannot be accepted, therefore, as proved that a specific organism is the cause of "rheumatism," as it is quite possible that the organisms described are merely modified streptococci.[38] On the other hand, it is frequently the case that no microörganisms are found in the joint-fluid in acute articular rheumatism. In 270 cases reported by McCrae[39] the bacterial results were practically negative.

Aside from the especial infections mentioned, articular complications have been recorded as accompanying the following conditions: Cerebrospinal meningitis, diphtheria, dysentery, mumps, gout, glanders, measles, scarlatina, erysipelas,* pertussis, puerperal fever, pyemia, septicemia, small-pox, tonsillitis, typhus fever, and possibly malaria. Joint inflammation may also occur after the use of sounds and catheters.

ARTHRITIS DEFORMANS.[50]

Synonyms.—Rheumatic gout; rheumatoid arthritis; osteo-arthritis; dry arthritis; proliferating arthritis; chronic rheumatic arthritis; nodular rheumatism; chronic rheumatism; nodosity of the joints; malum senile; rhumatisme noueux; arthrite séche, etc.

The name arthritis deformans is adopted for use here as involving no etiologic or pathologic theory, and as sufficiently descriptive. Names involving the use of the word "rheumatism" are undesirable, and the term osteo-arthritis has not only been used to designate one type of the general disease rather than the whole affection, but is still occasionally used in connection with tuberculosis.

Definition.—The disease is a non-suppurative, progressive affection of the joints, manifested by pain, swelling, and impaired function, and leading in many instances to stiffness and deformity. The disease is multiform in character, presenting many variations in type, but in general the character spoken of.

Symptoms.—The affection may be monarticular or polyarticular. It affects the hands or feet more frequently than other joints, the knee being the single joint oftenest attacked. The spine is attacked alone and in connection with other joints. In one group of cases the disease seems to attack the peripheral joints first, while in another group single joints nearer the trunk, *e. g.*, the hip, are involved.

The onset may be acute, in which case it resembles and is generally diagnosticated as acute articular rheumatism. In other cases it begins insidiously. In the insidious cases, which are the more common, the joint becomes irritable and perhaps painful on overuse, and stiffens a little after a period of rest, so that on rising after a period of sitting, the knee, for example, may be extended with some discomfort. Creaking in the joints may be among the earlier symptoms; this symptom, however, is not diagnostic. At this early stage some thickening of the joint membrane may be detected in superficial joints. Numbness in the affected joint, vasomotor disturbances causing reddening of the skin, burning, and a sensation of dryness may be complained of.

In some cases this early stage is accompanied by an impairment of the

FIG. 230.—ARTHRITIS DEFORMANS FOLLOWING GONORRHEA.
Considerable boggy swelling of, and effusion into, the joints. Ulnar deviation at the proximal phalangeal joints. Painful during active stage only (Bradford and Lovett).

general condition, loss of appetite, a slight elevation of temperature, and increase in the pulse. Periods of remission occur in all cases, which, as a rule, are characterized by acute attacks of greater or less degree during which the symptoms are accentuated.

FIG. 231.—ARTHRITIS DEFORMANS.
Bony enlargement of knees and effusion. Palpable fringes. Limitation of motion. Crepitus and pain on motion (courtesy of Department of Surgical Pathology of Harvard Medical School) (Bradford and Lovett).

At first stiffness is due to muscular irritability and spasm, and only in the later stages is it caused by mechanic alterations in the joint.

Joint effusion may or may not be present, a diffuse and pulpy swelling being more characteristic; later there is a fusiform swelling involving synovial membrane, capsule, ligaments, and bone.

Distortion of the joints may occur from muscular contraction, as in tuberculous joint disease, and in other cases from changes in the shape of the articular ends of the bones, contractions of the capsule, etc. In the hands distortion of the fingers to the ulnar side of the hand is common. This is generally accompanied by flexion, but may show hyperextension instead.


Fig. 232.—Arthritis Deformans of Long Standing (Heberden's Nodes) (Bradford and Lovett).

Varieties.—The more common varieties are:

1. A polyarticular type, generally involving the peripheral joints, more frequently affecting the young than do the other forms. Swelling occurs, but proliferation of bone is not in any event a marked feature. This type has been called the atrophic or chronic rheumatoid type, nodular rheumatism, or arthritis nodosa.

2. A monarticular variety, involving most often the larger joints, such as the hip or knee, attacks older patients, as a rule, and is likely to be characterized by a proliferation of bone, the formation of marginal exostoses, etc. It has been called the hypertrophic variety of arthritis deformans, osteo-arthritis, etc.

3. A third variety is characterized by synovial swelling and a late development of bony changes, but chiefly by a tendency to ankylosis in the affected joints. This variety is generally polyarticular, is seen in children, and has been called fibrinous


Fig. 233.—Arthritis Deformans in a Child (Still's Disease).

arthritis, arthritis fibrosa, the fibrinous type of arthritis deformans, ankylosing arthritis, infectious arthritis,[51] etc.

4. A fourth variety of the affection, not necessarily existing alone, is characterized by changes in the phalangeal joints of the fingers, beginning in the terminal articulations. These joints become knotted and distorted. These enlargements are known as "Heberden's nodes."

The description of these varieties is merely a grouping of the most commonly associated symptoms, and is not a constant grouping, for mixed varieties are to be seen.

In children[53] affected by arthritis deformans the same varieties seen in adults may be found, but more commonly a type originally described by Still, and frequently spoken of as "Still's disease,"[54] is encountered. In this type the affection is polyarticular, and joint thickening predominates over bony and cartilaginous changes. Glandular and splenic enlargement is common, and the onset is generally before the second dentition. The onset of the disease is most often diagnosticated as acute articular rheumatism, a diagnosis always to be made with great care in young children.

Diagnosis.—If the *x*-ray shows marginal deposits of bone and narrowing of the normal spaces occupied by the joint cartilages, the diagnosis is established. But one type of the disease has no such proliferation of bone, and here the *x*-ray will show but little. The existence of Heberden's nodes is often of value in identifying the disease.

From tuberculosis the affection is at times distinguished with difficulty, but *x*-ray changes are to be seen early in tuberculosis; the latter is in most cases an affection of childhood, and is more acute. In doubtful cases the joint should be aspirated and an inoculation made. From acute and subacute infective arthritis, especially of the type known as "rheumatic," the diagnosis of acute arthritis deformans is made often with great difficulty, as is shown by the few instances of the recognition of arthritis deformans as such in its acute stages. The relation of infection to arthritis deformans is by no means clear, and the only safe course for the surgeon is to remember that what appears to be simple "acute articular rheumatism" may eventuate in a chronic and progressive joint disease.

Prognosis.—The structural changes produced by arthritis deformans are permanent, so far as we now know. But the congestion accompanying the process, the synovial thickening, and similar changes are in many cases very much helped, if not cured, by appropriate treatment. In advanced cases, therefore, one can only hope to retard the destructive process; in early cases, on the other hand, an arrest of the process is to be hoped for in many cases, and in some a cure may be looked for. Some cases, on the other hand, seem to be resistant to treatment and progress uninfluenced by it. The prognosis in every case must be influenced by the patient's willingness to submit to treatment, for the knowledge of the disease obtained of late years has influenced the whole outlook in such cases, and it is no longer to be regarded as a hopeless condition, as it was in former times.

The disease in children may be wholly recovered from in some cases, although in general the outlook is not good.

Treatment.—The modern view of the disease emphasizes the cardinal importance of three things: (1) Increasing the patient's resistance by improvement of the general condition; (2) keeping efficient the elimination of waste-products by the skin, kidneys, and intestines; (3) improving the local circulation in affected joints and protecting them against trauma.

1. The **general condition** of the patient must be improved by methods generally recognized. Drugs have but little place in the treatment, except so far as indicated by anemia, debility, and similar factors manifest in the general condition.

2. **Elimination.**—The bowels must be kept active, and their share of the work of carrying off the waste must be efficiently performed. Equally important is the activity of the kidneys, which must be maintained at the highest available point. These measures lie in the domain of general medicine.

The activity of the skin is promoted by various measures, and hydrotherapy is perhaps the most important factor in the general treatment.

Electric-light baths are a means of inducing sweating at a lower temperature than is induced by the heat alone, the light apparently having some effect in bringing this about.

Hot-air baths to the whole body and baths of hot sand and of mud are used for similar purposes.

3. **Local Treatment of the Affected Joints.**—Arthritis deformans is characterized in nearly all cases by exacerbations in the affected joints, during which they demand especial treatment.

Treatment of Acute and Painful Joints.—In these cases the treatment is that of acute synovitis in general, and should be continued until the heat, pain, sensitiveness, and effusion, if it is present, have diminished, when they are by degrees discontinued. To fix such a joint over too long a time is to favor ankylosis, but ankylosis is also favored by the deposit left after each exacerbation, and exacerbations must be dealt with efficiently and not half treated.

Treatment of Chronic Joints.—Rest and exercise. A joint affected by this disease is vulnerable and resents overuse and trauma. Pain on use is an indication not to be neglected. Within this limit use is to be encouraged. Exercises to strengthen the muscles of an affected joint are of use and increase its endurance; such exercises may be given by a medical gymnast, or by means of some apparatus, such as the Zander appliances, or may be taken by the patient. Merely to straighten the knee ten or twenty times once or twice daily, without weight bearing, is helpful so far as it goes in affections of the knee-joint, and may be taken as a type of therapeutic exercise.

Massage is of value in removing waste-products from around the joint, stimulating the circulation, and strengthening the muscles. Electricity is of use in some cases. Other measures of value are local hot-air baths, the Bier congestive treatment, and the vacuum treatment, in which the affected joint is placed in a receptacle from which the air is exhausted.

Deformities.—If deformities exist, it is desirable, in most cases, to remedy them in order to allow locomotion. A flexed knee, for example, prevents walking, while a knee stiff in the extended position is useful. In patients of sufficiently good general condition, joints which are not useful on account of such malpositions may be corrected as in other forms of joint disease. Anesthesia and the use of moderate force are generally sufficient to bring about the result. Extensive operative procedures are not in general to be advised, but the removal of bony obstructions which restrict joint motion is to be undertaken when necessary, as, for instance, when marginal ecchondroses prevent motion.

TUBERCULOSIS OF JOINTS—TUBERCULOUS JOINT DISEASE.

Symptoms.—Tuberculous disease of joints is accompanied by a uniform set of symptoms which are in general the same whatever the joint affected. These symptoms, however, vary in their character and relative intensity according to the anatomic character of the joint affected, *e. g.*, the hip is a joint deeply situated and surrounded by muscles, whereas the knee is superficial and its synovial membrane is comparatively accessible to observation. The relative importance of joint swelling is, therefore, greater in the knee, because it can be more easily detected, and the reflex muscular spasm is our chief reliance in the hip.

General Symptoms.—*Impairment of General Condition.*—Loss of appetite, impairment of the general condition, loss of weight, pallor, and diminished resistance to fatigue, as a rule, precede the marked development of local symptoms. Retardation of general growth occurs during the active stage of the disease when the larger joints are involved, and especially in tuberculosis of the spine. Elevation of temperature accompanies the early and late stages of the disease when the patient is active or under ambulatory treatment. Leukocytosis is not often seen in tuberculous disease of joints.

Local Symptoms.—*Reflex muscular spasm,* a steady muscular contraction, reflex in character, affects the muscles controlling the affected joint from an early stage of the disease until the acute process is ended. It is the most constant and the most reliable of all the phenomena of the affection, is of the utmost importance in the diagnosis, and is expressed by a limitation of the normal arc of motion of the affected joint. It disappears under full anesthesia, to return with the return of the patient's consciousness. Its effect is to crowd the diseased ends of the bones together and wear them away where they are softened; it thus becomes a factor to be reckoned with in treatment.

Atrophy and Retarded Growth.—Wasting and retarded growth of the bones and muscles of the affected joint are early and constant symptoms. Atrophy of bone as an early symptom is found in the radiograph of the joint as contrasted with that of its normal fellow. It is shown in its earliest stages by a diminished shadow of the diseased articular ends, a greater contrast between marrow and cortex, and later by a diminution in the size of the bones of the diseased side, contrasted with the normal ones. The affected limb grows less than the normal one during the disease.

Swelling.—The characteristic sluggish and semifluctuating swelling of tuberculous synovial membrane is always present in tuberculous joint disease, and is easily detected in such joints as the knee, ankle, and wrist, etc. It is found only by the practised touch in the hip, and is not to be detected in the spine. Fluctuation, as a rule, is not present except in the early stages and in abscess of the joint.

Shortening of the diseased limb is due to one or both of two causes. The destruction of the articular surfaces of the bones is followed by ankylosis and retardation of growth during the acute process.

Distorted position of the affected joints is a common accompaniment of acute tuberculous joint disease, and is due to the muscular spasm described above. These distortions are easily remediable if treated early, by quieting the inflammation of the joint by proper treatment, but they are dangerous and threaten disability if allowed to go on uncorrected until ankylosis has occurred. In other cases the joint deformity is due to bony destruction of the joint surfaces, and the distortion is a result of that. This is seen especially in tuberculosis of the spine.

Pain is a symptom of varying severity.

Manipulation of any tuberculous joint is generally painful when passive motion is attempted beyond the arc easily allowed by the muscular spasm. Cases making good progress under treatment should not suffer spontaneous pain, and the occurrence of it is evidence of insufficient treatment or very acute disease.

Pain is *not* a diagnostic symptom. Although extremely suggestive, night-cries are not absolutely diagnostic of tuberculous joint disease, but occur occasionally in other forms of acute inflammation of joints. Tenderness over the affected joint may be present.

Lameness and impaired usefulness are due to two causes: (1) The pain caused by the use of the affected joint and the desire to spare it; and (2) the stiffness and possible distortion due to muscular spasm. These symptoms are most marked, as a rule, in the morning.

Complications.—*Abscess* is made evident by a fluctuating swelling at or near the affected joint; its appearance is not necessarily painful, yet it will generally be preceded by a painful period. The skin covering it is at first normal in appearance, and then is shiny as the cavity becomes distended. It finally reddens at the point of least resistance and breaks by one or more small openings. Or under favorable conditions it may disappear by a process of absorption. Abscess is not necessarily accompanied by leukocytosis or exceptionally high temperature.

Generalization of the tuberculosis in the form of tuberculous meningitis, pulmonary tuberculosis, and generalized miliary tuberculosis occurs in a certain proportion of all cases. Operative removal of the tuberculous foci is not a preventive of tuberculous generalization, but, on the other hand, operative interference is followed in a certain proportion of cases (estimated at 10 per cent. by Wartmann[5]) by a generalization of the process.

Amyloid degeneration of the viscera is a sequel of certain severe cases of long continuance in which, as a rule, suppuration has extended over a long time.

Diagnosis.—The diagnosis of tuberculous joint disease is in general to be made from the signs described above. The association of involuntary tonic muscular contraction with swelling of the joint and atrophy of bone and muscle is a very significant combination of symptoms in monarticular joint disease. When it occurs in a joint affection of chronic character and long continuance, especially in a child in the second dentition, it is probably, under these circumstances, joint tuberculosis. Further diagnostic aid may be obtained by the *x*-ray, which, except in the earliest stage, is likely to show diminished bone shadow and atrophy of bone, with possibly irregularity of outline of the articular end of the bone when destruction of bony tissue has occurred.

Positive information as to the character of the disease can generally be obtained by the *microscopic examination* of tissue removed from the joint. In the contents of abscesses, however, it is generally difficult to identify the tubercle bacillus, and its absence is not of diagnostic importance.

Inoculation of the contents of the abscess or of the joint-fluid into a guinea-pig affords a definite and reliable means of diagnosis.

Cultures of the fluid from joints or abscesses in suspected cases if sterile are suspicious, but this is not conclusive, on account of a possible error in technic.

Tuberculin.[61]—The use of tuberculin for diagnostic purposes does not yield sufficiently reliable results to enable one to speak positively in any given case.[60]

Differential Diagnosis.—Tuberculous disease of the joints is at times diagnosticated with difficulty from the following conditions:

Acute traumatic synovitis (p. 299).

Acute synovitis of the type described as "infective" may simulate the acute stage of joint tuberculosis, and in children especially the diagnosis must at times be delayed.

Acute Suppurative Arthritis or Osteomyelitis.—In the acute and severer cases the violence of the attack, the high fever, the leukocytosis, the rapid pus-formation, and the septic character of the symptoms will identify the disease. There are, however, cases of a more chronic character simulating tuberculosis so closely that a diagnosis may be a matter of doubt or impossibility without operation. With operation, of course, the presence of pyogenic organisms, such as the staphylococcus, the streptococcus, or the pneumococcus, clears the matter up.[8] In other cases the *x*-ray appearances may be those of acute osteomyelitis and not tuberculosis.

Arthritis Deformans.—The occurrence of monarticular arthritis deformans in childhood is rare. The characteristics of the affection are described in the section dealing with that affection.

Prognosis.—Tuberculous joint disease tends to be a self-limited disease and to end, under nature's efforts, in ankylosis to a greater or less extent of the affected joint, probably in a position of deformity. The result, both as to life and function, depends on the power of resistance possessed by the individual against the tuberculous invasion. If he has but little resistance and power of repair, the destructive element of the tuberculous process will prevail, destroy his joint, and probably end his life. If the power of repair is good, his life should be saved and the local process in time cured by nature's efforts. Modern surgery attempts to increase the power of resistance and to place the affected joint under conditions favorable to repair. As to life, it is probable that in tuberculous disease of such joints as the spine and hip the mortality near and remote is not less than 30 per cent. In the other joints it is less, but no accurate figures can be given. Just as in pulmonary tuberculosis, the florid type of the disease is attended by much greater risk to life than the more chronic type.

The prognosis is better in children than in adults, and in both the existence of a markedly tuberculous family history is an unfavorable factor.

As a rule, abscess accompanies the severer grade of cases, but its occurrence in children does not essentially modify the prognosis. In adults it makes the outlook distinctly worse, and is an unfavorable sign of much importance.

The likelihood of such complications as tuberculous meningitis, phthisis, and general tuberculosis must be borne in mind in framing the prognosis.

Prognosis as to function will be discussed under the separate joints.

Treatment.—The treatment of tuberculous joint disease is both general and local.

General treatment, which is of the greatest importance, is coming of late to be more carefully followed out than was the case twenty years ago. With the recognition of the pathologic nature and natural history of the disease the importance of increasing the resistance of the patients by every means in our power has come to be fully recognized.

Out-of-door life is of the first importance in the treatment. The modern recognition of this fact finds its expression in the seashore and country homes so rapidly developing in this country and in Europe for the treatment of tuberculosis, and especially tuberculosis of the joints in children.[9] This should include not only life out-of-doors during the day, but during the night as well. Although this routine is most easily and pleasantly carried out in a warm climate, it is available and not unacceptable in the case of children in so severe a winter climate as that of New England. In the country, fifteen miles from Boston, Mass., the children with tuberculous joint disease in the Convalescent Home of the Children's Hospital have lived and slept in open sheds winter and summer since December, 1903. These sheds are heated on the coldest nights to about 40°, and the children are warmly clad, with head and ears protected by caps. The effect noticed has been a marked increase in appetite, improvement in general condition and vigor, and increased percentage of hemoglobin. The time is too short to speak definitely of the effect on the local process, but from the figures collected it would appear that the local processes have been favorably influenced. Even in the hospital class of out-patients some modification of this routine is possible and should be taken into account in *every case* of tuberculous joint disease.

Nourishing food and forced nutrition are obviously indicated in such cases, along with as favorable an environment as may be obtainable. It is evident that children and adults with tuberculosis of one of the larger joints should be restricted in their activity, and that the active day should be shortened by at least one-third in acute cases, and in cases showing signs of irritability and exhaustion complete recumbency, or recumbency for any part of the time, may be required. Such restriction also affects favorably the local process in disease of joints of the lower extremity by diminishing the traumatism induced by activity. Beyond the use of tonics when required, the tendency of modern opinion is to the effect that treatment by drugs is of little or no value, and is at times harmful, inasmuch as it tends to divert attention from the really important measures just discussed.

Local Treatment.—Local treatment aims at placing the affected joint in the state most favorable for repair.

Mechanic Treatment.—The chief aim of mechanic treatment is to diminish traumatism to the affected joint. The aims desired in mechanic treatment are accomplished by one or more of three methods:

(*a*) *Fixation* of the affected joint. (*b*) *Protection* from weight bearing in joints of the lower extremity. (*c*) *Traction,* to separate the diseased joint surfaces and to antagonize the wearing away of articular surfaces induced by the constant muscular pull.

These will be discussed in speaking of the special joints.

In addition to mechanic treatment certain local measures must be discussed.

Counterirritation, inunction, blisters, cauterization, and similar measures have fallen into merited disuse, since a more adequate knowledge of the pathology of joint tuberculosis has shown us of how little use such superficial measures are likely to be.

Bier's Congestive Treatment.—Passive congestion of the affected joint has been used as a means of retarding the activity of the tuberculous process and hastening the process of repair.

The application of it is as follows: An elastic bandage is applied by several turns around the limb above the diseased joint sufficiently tight to cause a venous hyperemia of the tissues beyond the bandage. It should not be applied so as to cause pain or coldness or to obliterate the pulse below the joint. The bandaging of the limb below the affected joint is not necessary. The extreme time of application is three hours daily, which should be reached by gradual stages and never exceeded.[14]

x-Ray Treatment.—The exposure of the affected joint to the *x*-rays has been somewhat used, but individual and collective experience has not, as yet, shown the method to be of any general value.

Compression of the affected joint by a flannel bandage is of use in the wrist, knee, ankle, and similarly situated joints, in addition to the measures described.

Operative Treatment.—The measures in common use may be grouped as follows:

Incision of the joint may be required—(1) to relieve intra-articular tension, especially in deep-seated joints like the hip. (2) It may be required for the relief of abscess which has or has not perforated the joint capsule. (3) It may be required in cases where exploration of the joint is necessary for diagnosis, for the removal of specimens for examination, for the removal of sequestra, or for similar reasons.

As a curative measure it has no effect alone or in connection with flushing, on the joint disease. If a tuberculous joint is opened and drained, no matter how carefully it is dressed, in time it will become infected with pyogenic organisms and both a pyogenic and tuberculous infection will be present. It is this consideration joined to that of collective clinical experience that has led modern orthopedic surgeons to an extremely conservative view with regard to operations on tuberculous joints.

Removal of Tuberculous Foci.—When they are somewhat remote from the articular surface and clearly defined, their removal by incision and curettage is warrantable. Where they are large and ill defined, or involve much of the articular surface, their removal is not, as a rule, satisfactory.[16] After removal the cavity is wiped with crude carbolic acid and alcohol, or with a $2\frac{1}{2}$ per cent. solution of formalin, and closed.

Erasion of the joint (arthrectomy) is chiefly advocated in children where it is desired to save the epiphyseal lines and not affect the growth of the diseased limb. Ankylosis is the desired end result, and the removal of the synovial membrane is in many cases a satisfactory operation followed by cure. It is to be undertaken only after conservative treatment has failed to control the progress of the disease; it is not suited to adults, and is of most use in superficial joints like the knee and elbow, where most of the synovial membrane is accessible.

Excision (*resection*) of the diseased joint is reserved for the severer cases, and is to be used only—(1) Where mechanic treatment has failed to relieve symptoms; (2) where a sequestrum involving a large part of one of the articular ends is present; (3) where drainage by other means fails and sepsis is present; (4) and where the general condition is rapidly failing and radical measures are demanded.

In the matter of excision the tendency to conservation has grown with our better understanding of the pathology of the disease and our better facilities for carrying out properly the mechanic treatment, along with the intelligent use of the open-air treatment.

Amputation need hardly be discussed in this connection, but is occasionally necessary in very severe cases of neglected joint tuberculosis or where excision has failed to relieve the disease.

Tuberculosis of the Hip.

Synonyms.—Hip disease; hip-joint disease; coxalgia; coxitis; morbus coxa; chronic articular ostitis of the hip. French: Coxo-tuberculose; coxalgie. German: Tuberculose des Hüftgelenks.

Symptoms.—The division of hip disease into stages has no pathologic or clinical basis. The early symptoms, however, are different from the later ones, chiefly in degree. Following a period of loss of appetite and impairment of the general condition, the child is noticed to favor one leg, or to be a little stiff in the morning; the lameness often wears away during the day, and periods of intermission are frequent; night-cries may be present, some slight wasting of the thigh is generally to be found, and the child tires easily and generally walks with a limp. In other cases the onset may be so sudden as to suggest a traumatic origin.

The symptoms of the developed disease are as follows:

Reflex Spasm.—The characteristic loss of motion in hip disease, which is always suggestive, is a loss of hyperextension, abduction and internal rotation when the leg is flexed to a right angle. Flexion is later affected, and the limitation of motion increases in all cases in which the disease is increasing. The muscular spasm may extend to the lumbar muscles when the child is laid on the face and the spine hyperextended.

Fig. 234.—Obliteration of Gluteal Fold in Hip Disease of the Right Side (Bradford and Lovett).

Atrophy.—A diminution in the size of the muscles is noted in the early stage, and a tape-measure will detect a difference in the circumference of the thighs from ½ to 1½ inches, and about half as much in the calf. There is also atrophy of the gluteal muscles, and the fold of the buttock on the affected side is likely to be obliterated, partly as a result of muscular atrophy and partly of swelling. The atrophy involves the bone as well as the muscles, and is manifested by the x-ray.

Swelling.—In the hip this symptom is of less importance than in the more superficial joints, and frequently escapes observation; it is to be detected by the trained hand as an increased resistance over the anterior surface of the joint, in the more marked cases appearing as an ovoid swelling directly over the front of the hip-joint. In cases of acetabular disease the finger introduced into the rectum detects a fullness on the inner side of the pelvis under the acetabulum.

Shortening.—Shortening occurs when the disease has existed long enough to have caused a noticeable retardation in the growth of the limb, and later in the disease when there has been a destruction of bone in the femur or acetabulum which results in a loss of bone and a consequent pulling upward of the entire leg. If the length of the legs is measured from the internal malleolus to the anterior superior spine of the ilium,* with the legs parallel and in their normal relation to the pelvis, the difference in length represents what is spoken of as "real" or "bony" shortening, and represents the actual loss in the length of the bones of the leg. If the measurement, however, is taken from each of the internal malleoli, to the umbilicus* when the legs are parallel, the difference represents what is spoken of as the "practical" or "apparent shortening," and represents the tilting of the pelvis caused by the adduction or abduction of one of the hips.

Malposition.—If the joint is nearly or wholly stiff from the tonic muscular spasm spoken of above, the limb is likely to be held in an abnormal relation to the pelvis, and this abnormal position of the limb may consist of a flexed position, or, most often, a position of flexion combined with external or internal rotation and adduction or abduction.

If malposition of one hip, due to tonic muscular spasm, in a position of adduction, for example, is present, the pelvis must be tilted in order to allow the legs to be brought parallel, and the anterior superior spine of the adducted side will be raised and that of the other side will be lowered. If abduction of the leg is present, the abducted side of the pelvis will be tilted down and the adducted side up in relation to the transverse axis of the body. If flexion of the limb is present, the patient will lie with the knee of the affected side flexed, and if the knee is brought down to the table, the lumbar spine will be arched upward.

The malpositions induced by tonic muscular spasm are sometimes spoken of as the "fixed deformities of hip disease," and are accountable for much of the lameness in walking. If they exist, they must be remedied by treatment, or ankylosis in a position of deformity is likely to follow.

Pain.—The pain of hip disease, which is an early but by no means constant symptom, in nearly all cases is felt in the knee rather than in the hip, and sensitiveness to jarring the limb may become a permanent symptom. The location of the pain at the knee-joint is explained by the intimate relation of the sciatic, obturator, and anterior crural nerves. Extremely painful attacks are frequently followed by abscesses. In a few cases the pain is referred to the joint itself.

A characteristic manifestation of pain in early hip disease is in the form of night-cries; they may, however, be entirely wanting in certain cases, and may occur in other affections of the hip than hip disease.

Lameness.—The characteristic limp of hip disease is a prolongation of the normal period in which the weight is borne upon the affected leg, and it is expressed to the eye as a slight dragging of the affected leg and an unevenness of gait. If deformity is present, a very decided limp will be found, due to the fact that the leg is held in an abnormal relation to the pelvis.

Temperature.—In the majority of cases, in the active stages of hip disease under moderate treatment, an increase of the evening temperature of from one to four degrees is noticed.

*This method of measuring from a fixed point (the malleolus) to the movable point (anterior spine or umbilicus), which should be carefully marked and the scale read without touching the latter point, is much more accurate than the reverse.

Complications.—*Double Hip Disease.*—The disease seldom begins in both hips at the same time, and, as a rule, is fairly well developed in one hip before the other becomes involved. As a rule, it is of a severe type and tends strongly to ankylosis. Malpositions are common, are usually troublesome, and are frequently different in the two hips.

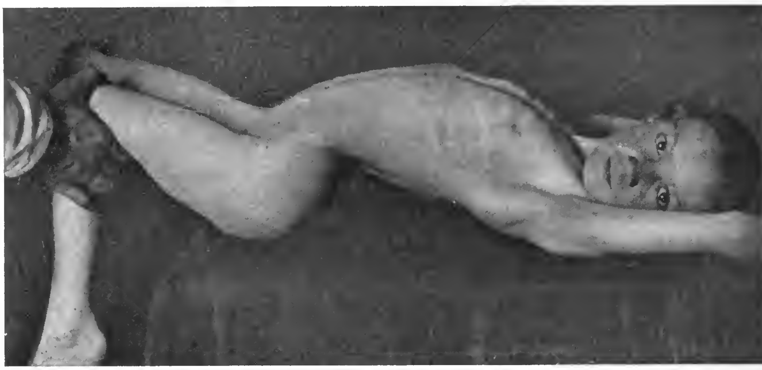

FIG. 235.—LORDOSIS IN DOUBLE HIP DISEASE PRODUCED BY EXTENDING THIGHS.

Abscess.—In a certain proportion of cases of hip disease suppuration occurs, but in a general way the percentage of abscess is influenced by the efficiency of treatment. As a rule, they are of articular origin, and their appearance in the superficial tissues implies a rupture of the joint capsule. They follow the lines of least resistance, and may appear at the front of the

FIG. 236.—SEVERE HIP DISEASE WITH EXTREME DEFORMITY AND ABSCESS.

joint, at the external aspect of the thigh, in the buttock, and more rarely in the perineum. Abscess from breaking down of the lymph nodes in the groin is not infrequent, and may exist independent of pus in the joint.

General Condition.—The general condition of the patient is likely to deteriorate during the progress of the disease, especially in cases characterized by suppuration.

Diagnosis.—Children and babies should be stripped naked for examination. Babies are most easily examined in the mother's lap; older children should be placed upon a hard table or on the floor, and should not be examined upon a bed or a sofa. Women and girls should have the underclothing removed from the waist down, and a sheet placed between the legs, leaving both hips open to inspection and manipulation. The diagnostic signs are:

1. Reflex spasm. 2. Atrophy. 3. Swelling. 4. Shortening.

Malpositions are the result of muscular spásm and do not constitute a separate diagnostic sign; pain is suggestive, but may be absent and has little diagnostic value; lameness may be owing to shortening, pain, or the malposition due to reflex spasm, and is not a separate diagnostic sign, although entitled to weight; the presence of abscess is entitled to weight as an indication of the presence of tuberculous disease. The character of

FIG. 237.—METHOD OF EXAMINING IN HIP DISEASE (Bradford and Lovett).

each of the diagnostic signs has been indicated in speaking of them as symptoms, and the technic of the examination for diagnosis will be dwelt upon.

The surgeon should stand beside the patient and take the lower part of the leg in one hand, while the other is placed upon the pelvis; the leg should then be fully flexed and extended to ascertain the normal range of motion. It should then be abducted, and after the test of this motion the leg should be flexed to a right angle and internal and external rotation should be tested. In this way the surgeon becomes acquainted with the normal range of motion and the patient becomes accustomed to the manipulation.

The leg of the diseased side is then taken in the same way and gently flexed until the range of motion is reached and the pelvis begins to move; this point of resistance should be noted and confirmed by a later manipulation. The leg should then be abducted, and the point when the pelvis begins to move again noted. The leg should be flexed to a right angle and, with a hand on the ankle, it should be rotated in and rotated out, and the limitation of motion again observed. These manipulations should be gentle and steady; to use a great force will overcome the muscular spasm, cause pain, and do harm to the joint, but restriction of motion means the restriction to gentle motion and not to an overwhelming manipulation. It is useful in doing this to distract the patient's attention, which will frequently eliminate voluntary restriction.

Measurement.—The measurements for atrophy and shortening should be taken, and the hand should then be passed over the anterior surface of both hip-joints to see if there is any thickening to be detected.

The Estimation of Malposition-flexion.—The presence and amount of malposition should next be investigated. The existence of flexion deformity in the limb is most easily detected by the Thomas method. If the leg of the well side is flexed until the knee touches the chest, in the normal person the popliteal space of the limb of the affected side will remain upon the table; if there is any loss of hyperextension, the popliteal space of the affected side will be raised from the table when the knee of the other side is flexed on to the chest. If it is desirable to measure the amount of flexion deformity present,[10] it may be done by the following method:

TABLE II.

In.	Deg.	In.	Deg.	In.	Deg.	In.	Deg.
0.5	1	6.5	16	12.5	31	18.5	50
1.0	2	7.0	17	13.0	33	19.0	52
1.5	3	7.5	19	13.5	34	19.5	54
2.0	4	8.0	20	14.0	36	20.0	56
2.5	6	8.5	21	14.5	37	20.5	58
3.0	7	9.0	22	15.0	39	21.0	60
3.5	9	9.5	24	15.5	40	21.5	63
4.0	10	10.0	25	16.0	42	22.0	67
4.5	11	10.5	27	16.5	43	22.5	70
5.0	12	11.0	28	17.0	45	23.0	75
5.5	14	11.5	29	17.5	47	23.5	80
6.0	15	12.0	39	18.0	48	24.0	90

The patient lies upon a table flat on his back and the surgeon flexes the diseased leg, raising it by the foot until the lumbar vertebræ touch the table, showing that the pelvis is in the correct position. The leg is then held at that angle, the knee being extended, while the surgeon measures off two feet on the outside of the leg with a tape-measure, one end of which is held on the table (so that the tape-measure follows the line of the leg) (*a b*); from this point on the leg (*b*), where the measurement of two feet ends, one measures perpendicularly to the table (*b c*), and the number of inches in the line (*b c*) can be read as degrees of flexion of

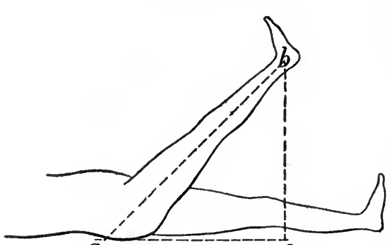

Fig. 238.—Estimation of Flexion (Kingsley).

the thigh by consulting table II. For instance, if the distance between the point on the leg and the table is $12\frac{1}{2}$ inches, it represents thirty-one degrees of flexion deformity of the thigh.

If the leg is so short that it is impracticable to measure off twenty-four inches, one can measure twelve inches; ascertain from here the distance to the surface on which the patient is lying in a perpendicular line in the same way, then doubling this distance and looking at the table as before, the amount of flexion is found.[10]

Abduction and Adduction.—It is important to estimate not only the presence, but the amount, of adduction or abduction present. Abduction and adduction of the hip, as such, are not noticed by the patient, but one leg is felt to be shorter or longer than the other, for adduction results in apparent shortening, and abduction in apparent lengthening.

If the right limb is fixed by muscular spasm in a position of adduction (*a e*), when the patient stands erect the legs must be made parallel to permit walking or standing, which can only be done by tilting one side of the pelvis up and the other down, and it will be seen in the diagram that the leg *a c* is carried up with that side of the pelvis, and that for standing and walking the leg *a c* is practically shorter than the leg *b d*. In the same way, if the leg *a c* is abducted to the position *a e*, the pelvis must be tilted in the opposite direction to make the legs parallel, because the angle *e a b* is a fixed quantity, and for purposes of standing and walking the pelvis must be carried down on the side *a* and up on the side *b*, resulting in apparent lengthening of the affected side.

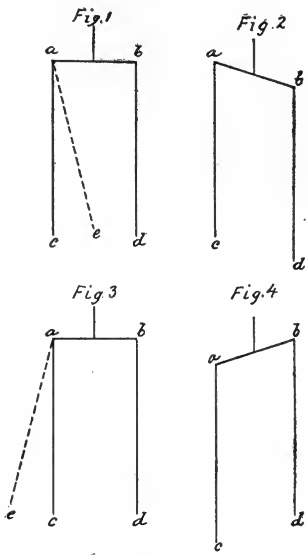

Fig. 239.—Diagram Showing Apparent Shortening and Lengthening of Leg Due to Tilting of the Pelvis (Bradford and Lovett).

A simple method has been devised by which it is possible to estimate with the tape-measure line the amount of adduction or abduction present. The following method is of practical value in use.[11]

The patient lies straight, with the legs parallel. Real shortening is measured with the ordinary tape-measure, and then apparent shortening is obtained in the same way. The difference between the two shortenings is seen at a glance. The only additional measurement necessary is the distance between the anterior superior spines, which is taken with the tape. Turning now to the table, if the line which represents the amount of difference in inches between the real and apparent shortening is followed until it intersects the line which represents the pelvic breadth, the angle of deformity will be found in degrees where they meet. *If the practical shortening is greater than the real shortening, the diseased leg is adducted; if less* *than the real shortening, it is abducted.* Take an example: Length (from anterior superior spine) of right leg, 23; left leg, 22½; length (from umbilicus) of right leg, 25; left leg, 23; difference between real and practical shortening, 1½ inches; pelvic measurement, 7 inches. If we follow the line for 1½ inches until it intersects the line for pelvic breadth of 7 inches, and we find 12 degrees to be the angular deformity, as the practical shortening is greater than the real, it is 12 degrees of adduction of the left leg.

DIFFERENCE IN INCHES BETWEEN REAL AND APPARENT SHORTENING.

DISTANCE BETWEEN ANTERIOR SUPERIOR SPINES IN INCHES.

1	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	11	12	13
¼	5°	4°	4°	3°	3°	2°	2°	2°	2°	2°	2°	2°	2°	1°	1°	1°	1°	1°
½	10	8	7	6	5	5	4	4	4	4	4	4	4	3	3	3	3	2
¾	14	12	11	10	8	8	7	7	6	6	5	5	5	4	4	4	3	3
1	19	17	14	13	11	10	9	9	8	7	7	7	6	6	6	5	5	4
1¼	25	21	18	16	14	13	12	11	10	9	9	8	8	7	7	7	6	6
1½	30	25	22	19	17	15	14	13	12	12	11	10	10	9	9	8	7	7
1¾	36	30	26	23	20	18	17	15	14	13	13	12	11	10	10	9	8	8
2	42	35	30	26	23	21	19	18	16	15	14	14	13	12	12	10	10	9
2¼	..	40	34	30	26	24	21	20	19	17	16	15	14	14	13	12	11	10
2½	..	..	39	34	29	27	24	22	21	19	18	17	16	15	14	13	12	11
2¾	..	..	..	38	32	29	27	25	23	21	20	19	18	17	16	14	13	12
3	..	..	..	42	35	32	29	27	25	23	22	21	19	18	18	16	14	13
3¼	..	..	..	..	39	36	32	30	27	26	25	22	21	20	19	17	15	14
3½	..	..	..	..	..	40	35	33	30	28	26	24	23	22	21	19	17	16
3¾	..	..	..	..	..	..	38	35	32	30	28	26	25	23	22	20	18	17
4	..	..	..	..	..	..	42	38	35	32	30	28	26	25	23	21	19	18

It is unsafe to make a diagnosis of hip disease without examining the spine in every case. The temperature of the patient should then be taken and he should be requested to walk, to lie down on the floor, and to get up, and should be watched for limitations of normal motion in the affected side and the character of the limp should be looked into.

x-Ray Examination.[12]—After the completion of this examination as described it is desirable to take a radiograph of both hips. The tube should be placed in a similar relation to both hips in the middle line of the body, and over a line connecting the two trochanters. Although the *x*-ray cannot be regarded as giving thoroughly reliable information, it is frequently of great value in establishing the existence of affections resembling hip disease, and also of indicating the existence and the nature of the process in true hip disease.

The first sign noted is a lightening of the shadow of the bone of the affected side in the neighborhood of the epiphyseal line. In cases of longer standing this becomes very marked, and a diminution in the size of the bone of the diseased side is noted, along with a sharp line between the cortex and the medullary line. Tuberculous foci of moderate size are to be detected, and erosion of bone in either the acetabulum or the head of the femur can be seen if it exists. A negative *x*-ray does not exclude hip disease, and pictures which show only a slight variation from the normal must not be allowed too much weight.

Differential Diagnosis.—The affections mentioned are those which in practical experience have proved to be the ones most frequently confused with tuberculous hip disease.

Synovitis of the Hip.—Acute synovitis of the hip, of traumatic, infective, or other origin, may occur in children and presents the symptoms of beginning hip disease. Atrophy, muscular spasm, night-cries, and malpositions may be present, and the distinction from true hip disease is to be made only by its relatively briefer course. In adults this difficulty arises less often than in children.

Acute Infectious Arthritis (Osteomyelitis of the Hip-joint).—This affection is of frequent occurrence, there being in König's collection 110 cases of acute infectious coxitis to 568 of tuberculous disease.[8] The symptoms are, as a rule, more acute and threatening, the swelling is greater, the temperature higher, and leukocytosis is generally present; abscess occurs early, and the diagnosis is often obscure until a culture can be made from the joint-fluid.

Chronic Arthritis Deformans.—Chronic arthritis deformans is rare in children except in cases in which other joints are affected. The presence of arthritis deformans in other joints would be chiefly relied upon to establish the diagnosis.

Lumbar Pott's Disease.—In cases of beginning psoas abscess the descent of pus in the psoas muscle may lead to a limitation of motion in the hip. As a rule, this is manifested as a loss of hyperextension and not of the other motions, but it may rarely occur as a general restriction of motion, and the hip symptoms may so closely simulate those of hip disease that it is impossible to say whether or not hip disease also exists.

The *x*-ray is of value, and if the symptoms are due to Pott's disease and the passage of pus near the hip-joint, they will, as a rule, subside under treatment.

Hysteric Affections.—With our better knowledge of joint disease the number of affections classed as hysteric becomes steadily less. Hysteric hip disease in children is rare, except as a very exaggerated sensitiveness of the joint causing often great distortion and an excessive limp. The symptom group is atypical. In young girls a hysteric exaggeration of a slight affection of the hip, such as synovitis, may give rise to much trouble in the diagnosis. In adults a traumatism to the joint is frequently followed by an unwarrantable prolongation of symptoms and a predominance of pain and sensitiveness, with an absence of the symptoms described as diagnostic of hip disease.

5. **Coxa vara** and fracture of the neck of the femur in children are frequently diagnosticated as hip disease. The shortening in fracture may be very slight, and the symptoms of joint irritation may be very acute soon after the accident; motion may be restricted in all directions, and the picture may be that of an early acute tuberculous hip.[13] Fracture or coxa vara should be distinguished by the fact that the trochanter is higher than Nélaton's line on the affected side, and that the limitation of motion should be in the line of abduction, while flexion is free; practically, however, Nélaton's line is hard to find in the child and the restriction of motion in the first week after a fracture is by no means always limited to abduction. The use of an *x*-ray in these cases is of primary importance.

Appendicitis occasionally simulates hip disease closely. A child will limp, and on examination the hyperextension of the affected leg will be found restricted, while other motions may be accompanied by some degree of pain. Diagnostic symptoms of hip disease in the way of swelling, shortening, etc., are absent.

Perinephritis is also to be mentioned as a cause of similar symptoms.

Malignant disease of the hip, which is very rare in children, would be for a time indistinguishable from hip disease, but the latter would manifest itself by greater swelling and characteristic symptoms.

Prognosis.—The prognosis of the general condition has been already discussed. It is probable that the susceptibility to tuberculous meningitis is greater in hip disease than in that of the other joints.

Prognosis as to Function.—Recovery with complete motion after tuberculous hip disease[20, 21] is rare, but occurs, and from this condition to recovery with complete loss of motion every degree is seen, varying with the severity of the disease in the individual case, the time the treatment is begun, and the thoroughness of that treatment. Recovery with ankylosis is to be expected in a certain proportion of all cases, but some limitation of motion is the rule. The prognosis of hip disease in adults is much less favorable than in children, both as to function and as to life.

Length of Treatment.—Active treatment of from two to three years will probably be needed in the average case at least, while protection to the joint will be required for at least two years more.

The prognosis as to lameness will depend largely upon the amount of malposition with which recovery occurs. Ankylosis in a position of deformity will be combined with marked lameness, but some shortening will be present in the majority of cases which have continued for any length of time. An average amount of shortening will be from one-half to two inches. It is probable that the shortening increases somewhat after the disease is ended, as the limb does not grow quite as fast as the other.

The significance of abscess is not great, and it does not affect the prognosis as to the limp, the amount of motion in the joint, nor does it seriously increase the prospect of shortening.

It is not infrequent in functionally good joints, where hip disease has occurred in childhood, that in adult life painful attacks occur from time to time which are rarely serious, but in certain cases may be the accompaniment of a relapse.

Double Hip Disease.—The prognosis in double hip disease is always serious, and the chances of a satisfactory functional result are small, as such patients get well, as a rule, with joints nearly or quite stiff, and although locomotion under these conditions is possible by abnormal mobility in the knee-joints, the condition is an unfortunate one and the prognosis under these conditions should be always most guarded.

Treatment.—The general treatment has been already discussed. The conditions determining the best treatment of hip disease are the result of the anatomic characteristics of the joint. It is a deep-seated joint with a comparatively small articular surface, and the muscles connecting the femur with the pelvis are the strongest in the body. When these muscles are in a state of spasm, they tend to crowd the head of the femur into the acetabulum with a great deal of force, and in the case of softened bone to wear away the articular surfaces. One aim of treatment is, therefore, to diminish this harmful contact, which is accomplished by—

1. Traction, in addition to which the other measures in general use in tuberculous joints are required—namely,
2. Fixation of the joint; and
3. Protection from the traumatism of weight-bearing.

For practical purposes it is desirable to divide the treatment of hip disease into—

A. Treatment of the acute stage.
B. Treatment of the subacute stage.
C. Treatment of the convalescent stage.

Treatment of the Acute Stage.—Treatment by recumbency is necessary when the disease is very acute and the hip is extremely sensitive, when deformity caused by muscular spasm is present, when abscess is present or threatened, and when the patient does not make proper progress under ambulatory treatment.

In carrying out the recumbency it is not sufficient to put the child to bed and allow it to roll around on a mattress, but a gas-pipe frame (Fig. 358) must be used, which is described in speaking of spondylitis. The patient is fastened to this bed-frame and traction is then made upon the leg, pulling in the line of deformity—that is to say, with the pelvis made square with the bottom of the bed, and with the sacrum and the lumbar spine nearly touching the frame. Traction of from five to fifteen pounds is used, the leg being pulled by a Buck's extension as applied for fracture of the femur. The amount of pull agreeable to the patient will be the proper amount to use.

The patient should be turned only once a day to have the bed-frame smoothed out and to have crumbs and irritating substances removed; at this time the back should be bathed with alcohol.

This treatment by recumbency should be continued until the acute inflammation has subsided, until the deformity has been reduced by easy stages toward the straight position, or until the abscess has shown marked signs of diminishing. The objection to the treatment by recumbency is the confinement of the patient. When possible, therefore, the treatment should be carried out in the open air. Recumbency for part of the day should be insisted upon during the acute stage of the disease.

Treatment of the Subacute Stage.—Treatment by ambulatory methods is always to be preferred when possible, and, except for the conditions enumerated above as indicating bed treatment, it is the usual and preferable treatment for hip disease. Traction is made upon the hip and some fixation is afforded by the use of the long traction splint which

FIG. 240.—HIP DISEASE WITH FLEXION DEFORMITY TREATED BY REST IN BED AND TRACTION IN LINE OF DEFORMITY.

is in general use in America. This is known[22] under the name of the Taylor and the long Sayre splint. The splint consists of three parts: the horizontal pelvic band, an outside upright provided with a traction appliance, and two posterior bands behind the thigh and calf. The pelvic band carries two perineal straps which furnish the countertraction, and passes around the pelvis below the anterior superior spines in front. This pelvic band is fastened to the upright at an inclination of 20 degrees from a right angle, the posterior part being higher. The outside upright runs down the outside of the leg to a point $2\frac{1}{2}$ inches below the bare heel. The bottom of the upright is turned at a sharp right angle and is furnished with a spindle on which are pins for making traction on the extension straps. The end of the spindle terminates in a square end-piece fitted to a clock key, and the spindle is controlled by a cog-wheel and spring.

This splint[22] should be worn day and night and only removed when absolutely necessary for purposes of cleanliness.

The patient wears a high shoe of three inches on the well leg, and uses crutches so that the splint swings clear of the ground. It is necessary to keep the traction straps tight by winding the windlass several times during the day, and in the case of intelligent parents, efficient traction, sufficient to modify the contact of the femur in the acetabulum, may be provided.[23]

The long traction splint should be worn until muscular spasm is absent when the leg is gently manipulated. During efficient treatment by this means, night-cries should be absent, extreme sensitiveness of the joint

Fig. 241.—Long Traction Splint.

Fig. 242.—Traction Splint Applied.

should not be present, and a failure to do well under this treatment is evidence of either the improper use of the splint or a severe grade of disease.

Treatment by fixation alone is much in use in Europe, and is from time to time advocated in this country. The objections to it are that it does not control the crowding of the head of the femur against the acetabulum. The treatment is fairly efficient, but probably is not followed by as good functional results as is traction. The aim of this treatment is expressed by a representative French surgeon as follows: "It is ankylosis in good position that we pursue as the ideal of a cure in coxalgia."[24] The hip-joint may be fairly well immobilized by a plaster-of-Paris spica splint reaching from the axillæ to the heel, but this can be made more efficient if the other limb is included by a double spica which, however, prevents locomotion. The main application of the method, however, is only to include the affected leg, with a high shoe on the well leg and crutches. The patient may go about wearing the plaster spica bandage, but if it is efficient, it is impossible for the patient to sit comfortably and is cumbersome and dirty. The spica should be applied with the leg fully extended and slightly abducted.

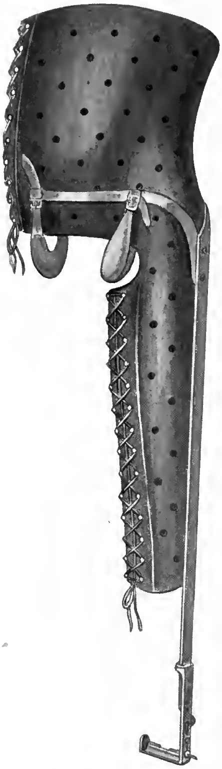

Fig. 243.—Lovett's Splint.

The use of a plaster spica bandage not including the knee, and allowing the patient to walk on the leg during the disease, is not in accord with what we know of the pathology of tuberculous joint disease and offers no advantages in controlling the disease.

The Thomas hip splint, which is used in England, is an appliance giving partial fixation to the hip-joint, but is not easily fitted. It consists of an iron bar extending down the back of the body and the diseased leg to a little above the ankle; the upper end of this is attached to a chest-piece which is at right angles to the upright and encircles the chest, fastening in front. There are two circles of iron which grasp the thigh and calf attached to the upright. The appliance is kept in place by a wide chest band and a bandage around the limb. It can be bent to fit any degree of flexion existing in the diseased leg, and applied to it in that position.[22] Fixation treatment should be continued until the indications given for discontinuing the treatment by traction are present.

Fig. 244.—Application of Plaster-of-Paris Spica.

Treatment by Combination of Fixation and Traction.—The most effective treatment of the subacute stage will be found to be the use of the long traction splint, but if it is evident that this does not furnish sufficient fixation to the affected joint, a plaster or leather spica should be worn inside of the splint. Most of the poor results from the use of traction in hospital practice are from the inefficient use of the traction splint, the constant activity of the patient, and consequent traumatism to the joint. It is probable that closer attention to the element of fixation in connection with this treatment will bring about better results.

Treatment of the Convalescent Stage.—When the symptoms of muscular spasm have subsided in the joint and the pain and sensitiveness are absent, and when the temperature in the afternoon is normal, it is reasonable to assume that cicatrization is taking place and that a more liberal use of the affected joint is proper. All that is apparently needed at this stage of the joint is that the full weight of the body should not be borne upon the affected joint until cicatrization has become firmly established. The simplest solution of the problem is to change the bottom of the long traction splint already spoken of, carrying it down into a crutch tip reaching two inches below the bare heel of the affected foot, when the band of the splint is in place; or by fastening it into a slot at the outer side of the ankle connected with a plate on the bottom of the shoe. When the weight is borne upon the splint, the heel of the affected side should not touch the heel of the boot, but the patient should remain suspended by a perineal crutch, the toe only touching the ground. In this way the impact of the step is broken and the hip is protected.

Fig. 245.—Plaster-of-Paris Spica Applied (Bradford and Lovett).

In older patients this splint may be arranged to go inside the shoe and may be jointed at the knee.[22] This splint is worn for at least two years after the cessation of active treatment, and discontinued gradually for an increasing period, the hip being carefully watched for symptoms of irritation. In cases of continued sensitiveness and weakness in the joint the splint must be worn for a longer time. The recurrence of muscular spasm is an indication for the reapplication of traction. Relapses are not uncommon, and occur both during the use of the protection splint and after its removal.

Treatment of Complications.—*Treatment of Abscess.*—In the early stage of abscess the patient should be treated by recumbency in the hope of absorbing the contents of the abscess, and in some cases this will occur. If the abscess is not absorbed, the possibility of aspiration and the injection of solutions may be considered.

If the abscess fails to be absorbed, or is seen too late in its history, or is evidently increasing, it should be incised.

The preferable proceeding is to open the abscess by a free incision, exposing most of its superficial extent. The cavity is

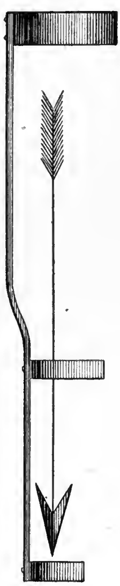

Fig. 246.—Diagrammatic Outline of Splint, Showing the Parallelism between the Body Portion and the Leg Portion (Ridlon and Jones).

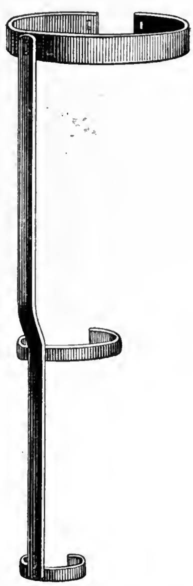

Fig. 247.—Showing the Splint in its Simplest Form, not yet Padded or Covered (Ridlon and Jones).

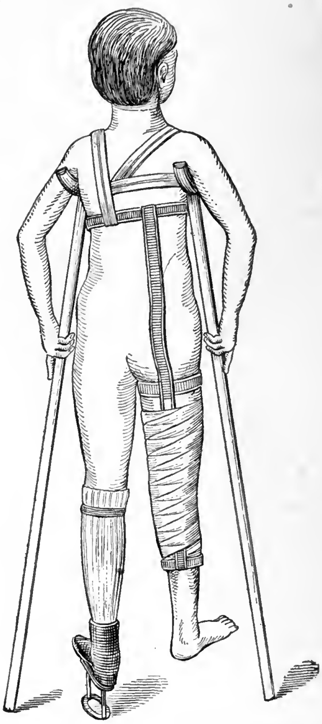

Fig. 248.—Thomas' Splint Applied.

then carefully washed, dried, and wiped out, and a dressing applied, but the abscess cavity not packed. Under these conditions certain abscesses will close almost by first intention, while others remain open, the result probably being determined by the extent and amount of breaking down in the original focus. To pack a tuberculous abscess, especially about the hip, is to insure the existence of a sinus from which pyogenic infection will ultimately occur.

When efficient treatment is carried out, abscesses occur, as a rule, only in the severer cases. In the treatment of abscesses it must be remembered that the tuberculous infection is not confined to the walls of the abscess, but exists in the surrounding tissue.

Deformity.—A recent case of deformity in an acute case of average severity should be reduced by traction in bed, as described above, in two or three weeks. If the deformity is resistant, or bed treatment is not possible, the patient should be anesthetized and the deformity reduced under ether, the fascia at the front of the hip being cut if necessary to facilitate this. In case of an attempt at reduction under an anesthetic, if too great force is encountered, it is wiser to abandon the operation and later to operate by osteotomy. After forcible reduction a plaster-of-Paris spica bandage should be applied.

Correction by Osteotomy.—In cases where there is reason to believe that the deformity is resistant to correction, or where bony ankylosis is obviously present, the proper means of bringing the limb into its proper place is by means of a subtrochanteric osteotomy, spoken of as the Gant operation.[25] The bone is nearly divided either obliquely or transversely by a linear osteotomy just below the level of the trochanter minor, and then broken. When the bone is broken, flexion, adduction, or abduction should be corrected, and as adduction is the most persistent deformity, an abducted position of the leg is generally desired, with a very few degrees of flexion if necessary. To secure abduction contracted fasciæ should be divided and the adductor tendons if necessary, which can be done subcutaneously. The patient should then be fixed in a carefully applied plaster spica bandage from the knee to the axilla, holding the leg in the desired position. Confinement to bed should last about six weeks, and fixation while the patient is going about for at least two to four weeks more. If the bandage is removed too early, the deformity may recur.

FIG. 249.—CRUTCH FOOT-PIECE FOR CONVALESCENT HIP SPLINT.

The ultimate results of this operation are most satisfactory, and not only is the position of the leg improved, but there is also noted a very marked improvement in the general condition of the patient.

Shortening Following Hip Disease.—In cases of considerable shortening following hip disease it is a matter of experiment in each case how to relieve the patient. Some will be relieved by wearing a high shoe, and it is not desirable to correct the whole amount of shortening at first. If the patient is not comfortable in the high shoe, all efforts to continue its use should be abandoned.

Double Hip Disease.—During the acute stage of the disease recumbency on a bed-frame or by traction splint on each side is the best treatment. After the acute stage is ended a double Thomas splint or a double plaster spica may be used, but it is desirable to carry traction further than in ordinary hip disease, on account of the generally unsatisfactory character of the results.

Operative Treatment.—*Excision of the Hip.*—The general indications for excision have been discussed in speaking of tuberculous joints. As applied to the hip, it

Fig. 250.—Convalescent Hip Splint, not Jointed at Knee.

Fig. 251.—Jointed Convalescent Hip Splint with Foot-piece Inside of Shoe.

is a particularly mutilating operation and leaves an imperfect and unstable joint. Moreover, excision of the hip means the removal of the head of the femur, and in cases of primary acetabular disease, the affected part of the joint is left practically untouched by the operation. The acetabulum may be removed by the operation of Bardenheuer, but the operation is a very extensive one and is to be undertaken only in exceptional cases. The mortality of excision of the hip *immediately after operation* is about 7 per cent. Considering the *ultimate* results in 50 cases reported from the Children's Hospital, Boston, there were 44 per cent. of deaths. In 99 cases reported from the Hospital for the Ruptured and Crippled, New York, the mortality was 51.5 per cent.[47] The causes of death after excision of the hip, aside from the small per cent. caused by operation, are due to the same causes as in hip disease not treated by excision, and excision cannot be regarded as preventive of general tuberculous infection.

Excision of the hip is indicated in adults in a larger percentage of cases than in children, on account of the greater severity of the disease and the fact that it is less amenable to conservative measures.

Functional Results.—After excision the mechanic conditions are not favorable to the formation of a stable joint, although from time to time exceptional joints are developed after excision, some of them allowing almost complete motion, but such joints are apt to be unstable and troublesome.

Although it is sometimes possible to gain thoroughly satisfactory results after excision of the hip, and at times one will regret not having performed it earlier, it is to be regarded as a measure to be undertaken only when conservative treatment has failed.

Amputation.—Amputation at the hip-joint in hip disease should be regarded as the very last resort at the command of the surgeon. It is to be undertaken only after excision has failed, or when the disease is so very extensive that excision would seem useless. It is to be regarded as a life-saving measure, and chiefly of use because of the very free drainage afforded to the affected parts. The amputation should be done subperiosteally. A case of re-formation of bone in the stump has been recorded.[22]

Tuberculous Disease of the Knee-joint.

Synonyms.—Tumor albus; white swelling; scrofulous disease of the knee; chronic fungous synovitis of the knee; chronic tuberculous osteitis of the knee.

Symptoms.—The beginning of the affection is, as a rule, insidious, being characterized by stiffness and limping; pain is present in the early stages, but night-cries are not common. The symptoms of the developed disease are as follows:

Reflex Spasm.—The limitation of motion in the knee-joint is always first noted in the direction of hyperextension; the joint is most often held in a position of slight flexion, and extension is resisted by a spasmodic contraction of the hamstring muscles.

Atrophy.—Wasting of the muscles, both of the thigh and calf, is present from an early stage and may reach a high degree; it is more evenly distributed than in hip disease between the muscles of the thigh and calf.

Swelling.—This symptom, which in hip disease is comparatively unimportant, in knee-joint disease is perhaps the most striking of all the signs. On inspection the knee will be seen to have lost its definite contour, the depressions at the sides of the patella are filled out, and the whole knee is involved in an ovoid enlargement. On palpation the swelling feels like a gelatinous mass, rather than a freely fluctuating synovial sac. In some cases the swelling seems to be very dense and of almost bony hardness; in other cases fluctuation in the joint is present. The swelling may be most marked over the tibial part of the articulation or over the femoral part; in the other cases the whole joint takes part in the enlargement.

Shortening.—Shortening is a much less important factor than in hip disease, and is not conspicuous until late in the history; on the contrary, it is quite common to find lengthening of the affected leg. This is due to the fact that the least growth of the leg in length takes place at the hip and ankle and the greatest part of the growth takes place at the knee, *i. e.*, in the lower epiphysis of the femur and

Fig. 252.—Tumor Albus with Flexion and Sinus.

Fig. 253.—Tumor Albus with Abscess.

the upper epiphysis of the tibia (*cf.* p. 344). The constant engorgement of this area with blood stimulates growth and leads to a temporary lengthening of the limb. It is not uncommon to find the diseased leg one-half of an inch longer than the other. In severe cases the destruction of the bony surfaces of the knee-joint causes shortening; this, however, occurs only in the severe type of the disease.

Malposition.—In untreated cases flexion increases from the beginning until it may reach a right angle, or even more, and one of the obstacles in the treatment of this affection is the persistent tendency of the flexed position to recur. In addition to the flexion, subluxation of the tibia backward occurs at a later stage of the affection as a result of the persistent pull of the hamstring muscles, which draws the tibia backward under the femur, a condition which is favored by the shallowness of the articular surfaces of the tibia. If the leg has assumed this distorted position and is straightened without an attempt to relieve the subluxation, the tibia will lie in a plane back of that of the femur. In addition to these two malpositions, the result of long-continued muscular spasm, is the external rotation of the tibia upon the femur, which accompanies severe grades of the disease, and which is also inclined to persist after the leg is straightened. Knock-knee is apt to be present in the later stages.

Pain.—The pain in knee-joint disease is located in the joint and may vary from a discomfort on jarring and aching after use to an exquisitely painful condition of the joint.

Lameness.—The characteristic lameness of knee-joint disease in the early stages is a short period of weight-bearing on the affected leg, on account of the pain caused, and in the later stages the gait is an awkward one, on account of the flexed position of the leg, the patient walking upon the toe and making progress with much effort. Sensitiveness is generally felt over the inner aspect of the joint over the patella.

Heat of the diseased joint is present, and is a valuable indication of the progress of the case.

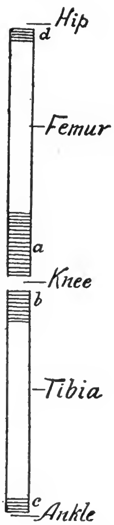

FIG. 254.—DIAGRAM TO SHOW THE SMALL AMOUNT OF GROWTHS OF THE LEG IN LENGTH AT THE HIP AND THE ANKLE AND THE VERY LARGE AMOUNT AT THE KNEE, ESPECIALLY AT THE LOWER END OF THE FEMUR. HENCE THE IMPORTANCE OF PRESERVING THE EPIPHYSEAL CARTILAGE IN YOUNG CHILDREN (Keen).

Complications.—*Abscess.*—Abscess may be present either in the form of a purulent distention of the joint cavity proper, or as a collection of pus which has burst through the cavity and appears in the peri-articular tissue.

Diagnosis.—The diagnostic signs in tuberculosis of the knee-joint are an intermittent lameness, accompanied by a general enlargement of the knee-joint, which is not generally clearly fluctuating, but a dense, boggy swelling accompanied by heat, tenderness, and muscular rigidity. The duration of the affection is of importance in making the diagnosis. The x-ray is of less value than in hip disease and, until the later stages, is not likely to give definite information.

Differential Diagnosis.—The diagnosis of tuberculosis of the knee-joint is not always an easy one, and must be made with care and often only after a period of observation. The conditions most frequently mistaken for it are as follows:

Chronic Synovitis.—The diagnostic signs of the various forms of chronic synovitis have been considered in speaking of that affection, and no general rule can be given for its differentiation from tuberculosis. The infrequency of chronic synovitis in children, the density of the swelling, the progressive character of the affection, the presence of muscular irritability and spontaneous pain should all be considered as pointing toward the probable existence of tuberculosis. The diagnosis of chronic synovitis of the knee-joint in a child is to be made with safety only after recovery has occurred.

In adults chronic synovitis of long duration may be accompanied by symptoms of considerable acuteness and a good deal of dense swelling; and in some cases a proper diagnosis of a tuberculous affection can often be made only after several examinations.

FIG. 255.—EARLY TUMOR ALBUS FOCUS NEAR EPIPHYSEAL LINE OF FEMUR. Patient six years old.

Arthritis Deformans.—Tuberculous disease in children is very much more common than arthritis deformans, particularly of the monarticular variety. In adults the history of the affection, the involvement of other joints, the age of the patient, and the *x*-ray will generally serve to differentiate between the two conditions.

Hemophilia.—This condition, which very closely resembles tuberculous osteitis of the knee-joint and is frequently mistaken for it, is to be recognized by the existence of the bleeder's diathesis and the course of the case.

Peri-articular Disease.—The inflammation of bursæ, lesions of the tubercle of the tibia, peri-articular abscess, and similar conditions are to be differentiated by the absence of effusion in the joint and the different location of the swelling and sensitiveness.

Acute Rickets.—In young infants a nutritive disturbance of the epiphysis of the knee-joint may lead to swelling, flexion, pain, and sensitiveness. One or more, frequently several, joints may be involved, and a careful examination of the case will disclose a disturbance of nutrition manifested by the signs of rickets or scurvy; in addition to this the swelling is markedly greater at the epiphyseal line than over the joint.

Syphilis.—In young infants or in young children hereditary syphilis may be manifested by the osteochondritis of Parrot, which may be accompanied by a secondary synovitis. In these cases, however, as in

FIG. 256.—TUMOR ALBUS AND SUBLUXATION IMPERFECTLY REDUCED.

rickets, the swelling and tenderness are limited to the epiphyseal line and the x-ray will show characteristic changes.

Other affections should be clearly differentiated from the affection of the knee-joint by a knowledge of symptoms.

Prognosis.—The prognosis in an average case of tuberculosis of the knee-joint, treated comparatively early, is excellent. Perfect motion may be restored, but in general recovery will result with an incomplete arc of motion, and in severe cases with complete rigidity. The earlier and more efficient the treatment, the better the result. The disease is to be regarded as less serious than tuberculosis of the hip or spine, both as to life and function.

Treatment.—The three principles of treatment mentioned in speaking of hip disease are to be considered in treatment of the knee-joint. These are: A. Traction. B. Fixation. C. Protection.

In the knee-joint **traction** is required only when the joint is acutely sensitive and when it is desired to reduce deformity.

Fixation.—This, combined with protection, constitutes the treatment of knee-joint disease. If fixation is to be used, especially in acute cases, it should be as efficient as it can be made. Plaster-of-Paris is the most available means of accomplishing this, the leg being done up in a circular plaster bandage from the malleoli to the adductor tendons, as a short plaster bandage affords imperfect fixation, and with such a splint

A B

FIG. 257.—A, plaster cast properly applied to knee; B, plaster cast improperly applied to knee (Moore).

and a high shoe on the well leg, the patient may be allowed to go about. Children, however, are apt to walk on the leg under these conditions, and merely to fix the knee-joint and allow the weight to be borne on it is not sufficient treatment. Instead of plaster bandages, stiff bandages may be made of silicate of potash, leather, or celluloid cut down the front and laced so as to be removed. They are made by putting a circular plaster bandage on the leg, which is cut off and filled with plaster-of-Paris and on this as a cast the stiff bandage is constructed.

Protection.—Although protection may be sufficiently obtained by a high sole and crutches, in the case of children, at least, it is advisable to have some sort of a perineal crutch worn in order to prevent the bearing of the weight on the foot of the diseased side. The protection hip splint, described in speaking of the convalescent treatment of hip disease, is efficient and should be made high enough to allow the foot to swing.

The Thomas knee-splint is an inexpensive and efficient appliance. It consists of a perineal ring, two uprights, and bottom plate.[22] The ring is an irregular ovoid, flattened in front and sloping from within outward and from before backward, and fastened to the inner upright at an angle of 135 degrees. The two uprights, which are made of steel wire, run from two inches below the sole of the bare foot to the bottom plate, which consists of a base plate three inches in diameter, which can be made of an ordinary iron washer fastened to the bottom of the two uprights. A strap goes behind the knee and the ankle, connecting the two uprights, and just above and below the knee in front are the two bandages fixing the knee to the splint.

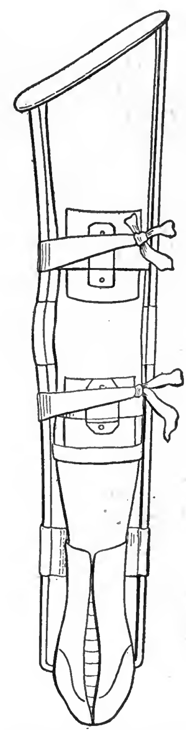

FIG. 258.—THOMAS' KNEE-SPLINT APPLIED.

This splint is used in addition to the plaster-of-Paris or other stiff bandage, contributing protection from weight-bearing while the plaster splint contributes fixation. The boot of the unaffected side is always built up to correspond to the length of the splint. With this splint the use of crutches is not necessary, although advisable in some cases.

Treatment of Convalescence.—When spasm and sensitiveness are absent, or in cases pursuing a very mild course, the Thomas knee-splint can be shortened and the ends of the upright, instead of being fastened to the base plate, can be turned at right angles toward each other and slotted into the sole of the shoe at such a place that the splint is too long for the heel to touch the ground. The patient then walks about suspended largely by the perineal ring and bearing but little weight on the diseased joint.

The discontinuance of the treatment is by the gradual omission of the splint and is governed by the same rules as those mentioned in speaking of hip disease.

Complications.—Deformity.—In the early stage of the disease flexion deformity is usually associated with an acutely sensitive condition of the joint, but later it may come on insidiously and without much pain. The deformity may be straightened as follows:

By *traction* in the line of deformity while the patient is in bed.

Reduction by a Series of Plaster Bandages.—In cases not characterized by extreme sensitiveness (in which, for example, flexion has come on before treatment has been begun) the application of an efficient plaster bandage to the knee in the position of deformity will so quiet the muscular irritability that at the next bandage, applied two weeks later, a greatly improved position may be secured. In this way lighter cases of deformity can be treated by a succession of plaster bandages without confinement to bed.

Reduction of Flexion under Anesthesia.—In cases where neither of these methods is applicable or effective, and in cases of long standing, reduction under anesthesia is advisable. In the lighter cases this is easily accomplished by the use of slight force. In the severer cases much force will be necessary and a genuclast has been devised by Goldthwait which corrects the subluxation at the same time that it straightens the knee. The apparatus consists practically of a wrench which pulls the tibia forward at the same time that it straightens the leg. The amount of force that it is safe to use, either with the hands or with the instrument, must be a matter of individual judgment. If the knee fails to be straightened by the application of moderate force, it is wiser to abandon the attempt and to proceed by one of the methods to be described. In case the resistance to correction seems to be offered by shortened hamstring muscles, they should be divided subcutaneously.

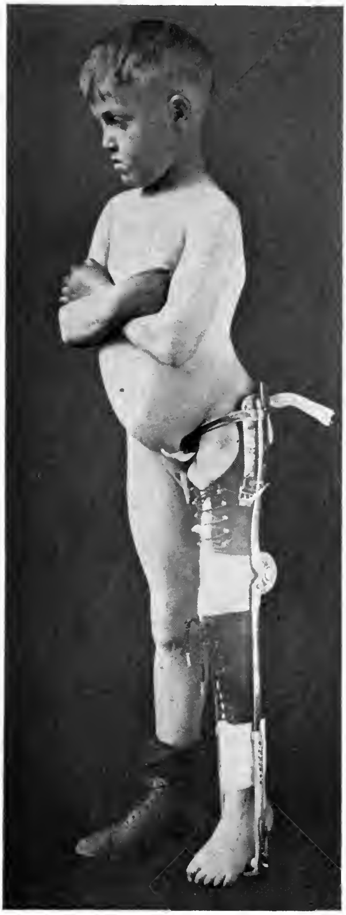

FIG. 259.—JOINTED TRACTION KNEE-SPLINT APPLIED (Bradford and Lovett).

Osteotomy of the Femur.—In cases of bony ankylosis, where the flexion deformity cannot be corrected by forcible straightening, osteotomy of the lower end of the femur, as near the epiphyseal line as possible, should be performed. The bone is divided nearly through, then is broken, and the knee straightened. The condyles of the femur are necessarily displaced forward to form an angle with the shaft, but the operation does not cause marked shortening of the limb. A similar osteotomy of the upper part of the tibia has been described for the same purpose. Osteotomy does not give a perfect cosmetic result, but is an operation of fair utility.

Excision of the Knee for Angular Ankylosis.—In cases of flexion deformity with ankylosis a wedge of bone may be removed from the knee-joint of such a size that the leg may be brought straight. The wedge, of course, has its base forward, and the planes of section must be made with great care.

Abscess.—The treatment of abscesses is the same that is recommended in speaking of the hip, except that they are more superficial and are less readily absorbed. At the time they are opened the joint is more easily

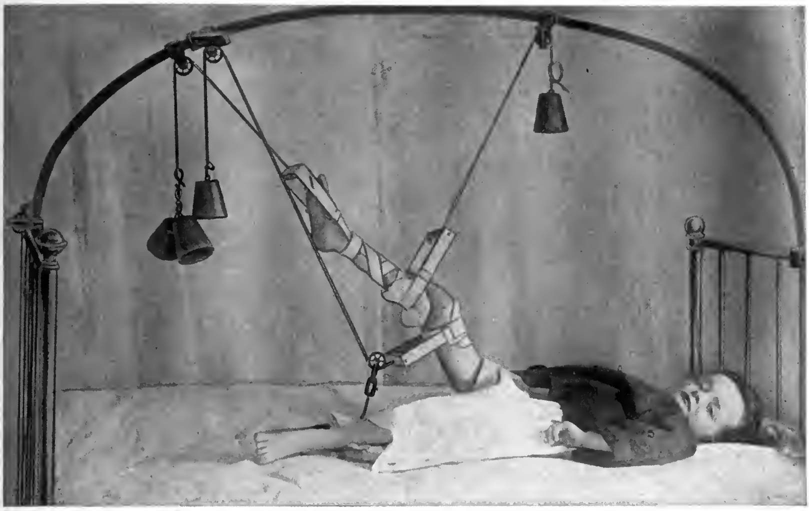

Fig. 260.—Reduction of Flexion Deformity by Traction.

explored and obvious foci of disease can be removed without unnecessary traumatism.

Operative Treatment.—Excision of the knee-joint is to be undertaken under the conditions described in the general section on Tuberculosis of the Joints. The functional results after excision of the knee, how-

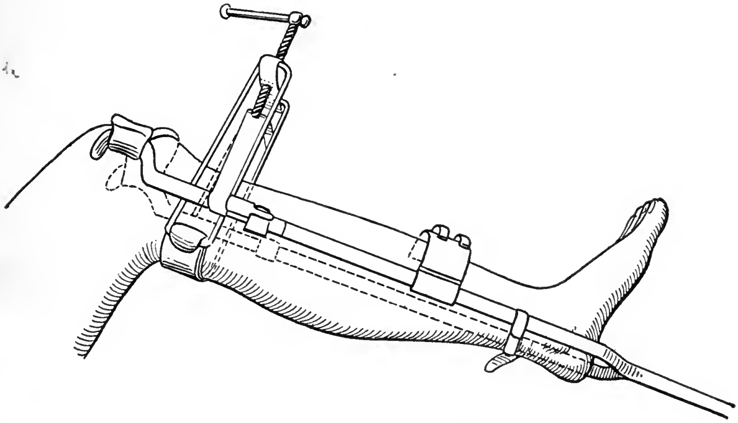

Fig. 261.—Genuclast (Hoffa).

losis of the Joints. The functional results after excision of the knee, however, are greatly inferior to the results after conservative treatment, and the tendency to flexion is not done away with by excision, as many cases have been reported where, after excision and apparent ankylosis of the limb, the disease has returned. Ankylosis, of course, is the object aimed at after excision.

It is extremely important in children that the epiphyseal lines should be saved in the operation, as otherwise a distressing amount of shortening may result from the destruction of these important centers; in the case of adults this is of no importance, but in the case of children this cannot be too strongly insisted upon. The reason for this is, as shown by Keen (Gray's "Anat.," ed. 1887, p. 276), that the growth in length at the knee from birth to adult life is the greatest in the entire body. The entire body grows only 3.37 times its length at birth, but the growth of the lower end of the femur is 7.30 times. If to this is added the growth at the upper end of the tibia, which is much greater than that at the lower end, the preservation of both epiphyseal lines at the knee is evident, almost imperative (Fig. 254).

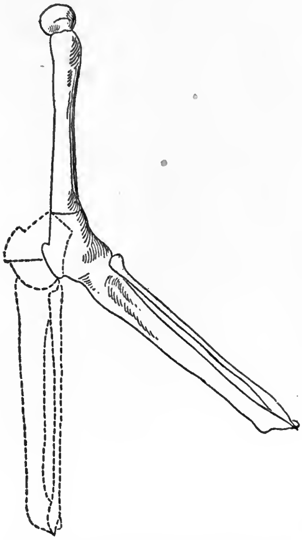

FIG. 262.—OSTEOTOMY FOR DEFORMITY WITH ANKYLOSIS (Hoffa).

The mortality of the operation in young patients is comparatively not far from 10 per cent. with ultimate results taken into account.

Arthrectomy or Erasion.—This operation has been proposed as a substitute for excision chiefly with children, and is described under operative surgery.

Amputation.— After excision has failed to remove the disease, or if the bones are hopelessly diseased in the first instance, the question of amputation comes up for decision. It should be regarded as a life-saving measure, and the only difficulty likely to arise is in the choice between excision and amputation in very serious cases. If the patient's reparative power is slight, amputation is to be preferred. Most patients, however, cannot be brought to consent to amputation so long as there is the slightest possibility that excision will give relief. In children the operation would only be advised when the joint was hopelessly disorganized and the shafts of the bone affected, and where prolonged treatment out-of-doors had failed to stimulate the reparative power.

TUBERCULOUS DISEASE OF THE SHOULDER-JOINT.

The general **symptoms** of tuberculous disease of the shoulder-joint do not differ essentially from those described in speaking of the other joints, except that the free mobility of the scapula makes the stiffness of the joint which results from the muscular spasm less evident, as the arm can be moved more freely. Examination, however, with the scapula fixed shows plainly that the joint itself allows little or no motion.

The disease is insidious, extremely chronic, and likely to impair the function of the joint. Wasting of the muscles becomes evident and involves those above the shoulder-joint as well as those below it, and the joint appears very prominent when compared with the other shoulder. Swelling is a most conspicuous feature, as the joint is superficial; the natural depressions around the joint become obliterated, and on examination a thick, resistant synovial membrane, with perhaps enlargement of bone, is to be felt. Shortening is not generally a symptom of importance.

Malposition.—On account of the mobility of the scapula malposition is not an important feature, and even in cases where the arm is held in a position of abduction, it still hangs at the side, the scapula tilting to allow it.

Pain is usually of a dull, dragging character, and may be referred either to the joint itself or to the middle of the arm.

Impairment of motion is present especially in rotation, but abduction and movements in the forward and backward plane are less limited. Suppuration is likely to occur.

Diagnosis.—The diagnosis offers no especial difficulty.

Prognosis.—The affection is always slow, and an impaired joint is likely to result, but ankylosis of the shoulder-joint compared with ankylosis of most joints is a matter of no great importance, the scapula acquiring extreme mobility in these cases.

Treatment.—Tuberculous disease of the shoulder-joint is best treated by fixation, the weight of the dependent arm, if kept at rest, serving to distract the joint surfaces, and only in very painful cases is traction by weight and pulley necessary. In such cases this is applied during recumbency, the arm being pulled in the line of deformity.

Excision of the joint should be performed if conservative treatment fails, and in very severe cases in adults.

Tuberculous Disease of the Elbow-joint.

Tuberculous disease of the elbow-joint is manifested by swelling and limitation of motion. This is generally first evident in a limitation of full extension of the forearm on the arm. Pronation and supination may remain free for a long time, when the radial joint is not involved.

Muscular atrophy is present, and swelling is noticed as a disappearance of the hollows at the sides of the olecranon, and the bony contour of the joint disappears in a fusiform swelling which often reaches a high degree. If tuberculosis of the head of the radius exists, the limitation of motion consists of loss of rotation, and a swelling over the radial joint is to be found. Shortening is not a matter of importance, but malposition is to be carefully prevented. The forearm tends to form an obtuse angle with the arm, which is a most undesirable position. Malpositions are, therefore, to be watched for and corrected as they occur, the arm being always kept at somewhat less than a right angle—say 70 degrees to 75 degrees—as that is the most useful position if ankylosis follows.

The **diagnosis** offers no especial difficulty.

The **prognosis** is not favorable for the reëstablishment of motion on account of the very complicated character of the synovial surfaces of the joint. Suppuration is likely to occur, and in many cases the joint degenerates into a pulpy mass involving the whole elbow.

The **treatment** consists in fixation of the elbow by a plaster-of-Paris or other splint, which, in connection with a sling, furnishes efficient treatment. Throughout the treatment the arm should be kept at less than a right angle with the forearm. Bier's congestive treatment is likely to be of use in diseases of the elbow.

If the disease progresses unfavorably in spite of conservative treatment, in severe cases in adults, the elbow should be excised. On account of the complicated character of the synovial membrane arthrectomy is not likely to be as satisfactory as in the knee.

FIG. 263.—TUBERCULOUS DISEASE OF THE ELBOW, WITH THE ARM FIXED AT AN OBTUSE ANGLE.

FIG. 264.—EARLY TUBERCULOUS DISEASE OF ELBOW.

TUBERCULOUS DISEASE OF THE WRIST-JOINT.

Tuberculous disease in this location is characterized by swelling, heat, and stiffness. The malposition most frequently found is the flexion of the hand on the forearm; swelling, obliterating the tendons and hollows of the wrist and presenting a fusiform shape, is a common symptom. Suppuration is liable to occur, and the course of the disease is usually long.

Treatment.—Fixation is indicated and is easily carried out by ordinary anterior and posterior splints, or by plaster-of-Paris or molded leather splint shaped to fit the arm. Compression is a valuable addition to the treatment, and Bier's congestive method is of use in addition to the mechanic measures. If the case proves to be resistant to conservative measures, and in the case of severe disease in adults, excision should be performed. Arthrectomy is not to be advised on account of the complicated character of the synovial membrane of this joint.

Fig. 265.—Tuberculosis of the Wrist (Moore).

Fig. 266.—Sacro-iliac Disease (Right Side) (Moore).

Tuberculous Disease of the Sacro-iliac Joint.

Synonyms.—Sacro-iliac disease; sacro-coxitis. French, sacro coxalgie; sacro re-theocace. Italian, malo di Boyer.

Tuberculosis[63] of the sacro-iliac joint is an unusual condition, and although more frequent in adults, is occasionally seen in children.[64]

Pain in the lower part of the back and discomfort in walking are the two most prominent symptoms. The pain is made worse by standing, and is generally relieved by lying down; it is apt to be more severe at night, and is increased by pressing the crests of the ilia together. It varies in situation and may be referred to the course of the sciatic nerve. The inflamed joint is sensitive to pressure posteriorly, and this may also be found over the anterior part of the joint, which can be reached through the rectum. In addition to the sensitiveness there is a marked swelling over the joint, which may go on to abscess. Abscess, however, may not point directly over the joint, but may burrow and appear in some neighboring part, becoming intrapelvic, or appearing in the ischiorectal fascia or in the buttock. It may also appear as a lumbar abscess slightly above the joint.

The gait is peculiar. The patient walks with the knees close together, taking short steps and disturbing the pelvis as little as possible. There is an entire absence of free stepping out, but a disposition to keep the feet close together and to shuffle along, perhaps leaning on a cane. In standing the weight of the trunk is thrown on the well leg, while the leg of the diseased side rests lightly on the ground. A marked lateral curvature of the spine is present, the body leaning very much to one side, even when the attempt is made to stand squarely.

Diagnosis.—The diagnosis rests upon the presence of tenderness and swelling over the sacro-iliac joint, tenderness upon pressing the ilia together, the lateral deviation of the spine in standing, and the peculiar gait in walking. The joint is accessible to the *x*-ray, and a good radiograph should identify the disease if sufficiently advanced.

The disease is most frequently mistaken for sciatica, lumbago, Pott's disease in the lower part of the spine, and hip disease.

Prognosis.—The prognosis is grave, and even in the cases of recovery the progress is slow and discouraging. In children it is likely to be accompanied by marked systemic infection.

Treatment.—In the most acute cases the patients should be kept in bed with a weight and pulley extension to the leg, to steady the limb. When recumbency is given up, a plaster-of-Paris spica bandage should be applied as far down as the knee to prevent motion of the hip-joint. This may be made of leather and may be removable, and should be so constructed as to be capable of being fastened tightly around the pelvis. In less severe cases a low, short plaster jacket with perineal bands may be sufficient to fix the joint. If abscesses occur, they should be opened, thoroughly disinfected, and drained.

Tuberculosis of the Ankle-joint.

Tuberculosis of the ankle-joint may be situated in the articular end of the tibia or in the astragalus, and the other adjacent bones may be involved secondarily or independently.

Symptoms.—The earlier signs of the affection consist of a painful swelling in the joint, accompanied by pain in walking, limp, and loss of elasticity in the gait.

Reflex Spasm.—The loss of motion at the ankle-joint is an early and characteristic symptom; dorsal flexion is earlier lost than plantar flexion, and adduction and abduction of the foot are less affected than the antero-posterior motions. If the tarsal bones only are affected, there is but little muscular spasm.

Atrophy.—Wasting of the muscles of the calf, and, to some extent, of the thigh, is a constant symptom.

Swelling.—The joint presents an ovoid swelling, generally most noticeable in front over the anterior surface of the joint; it extends, however, to the back of the joint in severe cases, the malleoli are lost, and the outline of the ankle-joint consists of a round mass without depressions. The swelling does not generally fluctuate, but is gelatinous and doughy. In the young, shortening of the leg and to a certain extent of the thigh occurs in severe cases from retardation of growth. In cases of severe joint disease there is also a loss of length in the leg from bony destruction.

Pain.—Pain is present, but is less acute than in the hip and spine; it is spontaneous and is excited by motion and use, and sensitiveness is present over the anterior surface of the ankle-joint, most often toward its outer side. Heat is perceptible on placing the hand on the joint.

Complications.—Abscesses may occur and are generally superficial and more like those at the knee than at the hip.

Deformity.—The deformity generally is in a position of plantar flexion of the foot, resulting in a position of talipes equinus, although the reverse may be noted, resulting in talipes calcaneus. In exceptional cases the sole of the foot may be inverted or everted, but in general malpositions of the ankle are comparatively uncommon and easily controlled.

Fig. 267.—Tuberculosis of Ankle with Sinuses (Front View).

The *x*-ray gives most valuable information, and on account of the easy penetration of the rays, the greatest details of the bone structure can be shown, enabling one to locate with considerable accuracy the seat of the disease.

The os calcis, the scaphoid, the cuboid, and the other bones of the ankle may be involved primarily by a tuberculous invasion. In these cases the symptoms consist largely of pain, lameness, and localized swelling, and the motions of the ankle-joint may be but little involved. The disease is recognized by the location of the swelling and tenderness, and by the aid of the *x*-ray.

Diagnosis.—The diagnosis of tuberculosis of the ankle-joint has been sufficiently described in speaking of the symptoms.

Differential Diagnosis.—The conditions most frequently mistaken for tuberculosis of the ankle-joint are as follows:

Chronic Sprain of the Ankle.—This is almost entirely confined to adults, the *x*-ray shows no focus of disease, and the history is characteristic.

Inflammatory Flat-foot.—Under certain conditions this may present a striking similarity to tuberculosis of the ankle-joint, and is to be identified by the same means described in speaking of chronic sprain.

Arthritis Deformans.—This should be recognized by the signs described in speaking of that affection.

Prognosis.—In ankle-joint disease of average severity treated early the prognosis is excellent for recovery with good functional result; even if ankylosis occurs in the affected joint, the other joints of the foot become more movable and permit a usefulness of the foot that is surprising. The prognosis is better in disease of the tarsus than when the astragalotibial joint is affected. The prognosis in adults is less favorable than in children.

Treatment.—The treatment consists in fixation and protection, traction being inapplicable.

Fixation is most easily furnished by a circular plaster-of-Paris bandage which should be carried above the joint. In long-continued cases a leather splint may be substituted for plaster-of-Paris.

Protection from weight-bearing may be furnished, as in the knee, by putting a high shoe on the well foot and using crutches, or by means of a splint. The use of the Thomas knee-splint, in connection with the plaster-of-Paris bandage to the ankle, is, on the whole, the best treatment.

FIG. 268.—BRACKETED PLASTER SPLINT FOR FIXATION OF ANKLE AFTER OPERATION.

If abscesses form, they are not likely to absorb and should be incised, and if bone foci can be easily reached at the same time, they should be removed. If the foot assumes a malposition, this should be corrected by applying a series of plaster bandages to the foot in its position of deformity, thus quieting the inflammation, and at successive applications securing an improved position. Bier's congestive treatment is applicable and advisable in cases of tuberculosis of the ankle.

Operative Treatment. — Operative treatment is to be undertaken under the same conditions as have been mentioned in the general section.

The results of operation upon the ankle-joint are not brilliant, as the communication of the synovial membrane is so free that it is harder than in the other joints to remove enough of the diseased tissue to secure immediate healing. The mildest form of operative interference consists in curetting the sinuses and removing foci of bone identified by the x-ray or found on opening abscesses. It is rarely a satisfactory procedure except in the cases of sharply limited foci.

Excision is a more satisfactory but deforming operation, and frequently results in a malposition of the foot which may be troublesome throughout life.

Amputation is to be considered under the same conditions that were spoken of in tuberculosis of the knee-joint.

COXA VARA.

Synonyms.—Incurvation or infraction of the neck of the femur. German, Schenkelhalsverbiegung. French, Deformation du col du femur. Ital., coxo varo.

The name coxa vara is applied to the condition in which the neck of the femur is depressed below its normal obtuse angle with the shaft sufficiently to give rise to symptoms in the hip-joint.

In coxa vara the first symptom noted is generally a limp in the affected hip, associated in older patients with a feeling of shortness in that leg. The joint is irritable, certain motions are painful, and use is followed by discomfort and aching.

On examination, the affected leg, in unilateral cases, is found shorter than the other; the top of the trochanter is above Nélaton's line, and generally a little back of its normal position; the trochanter is prominent outward and further from the middle line of the body than its fellow; the foot and leg are generally rotated outward, and although the motions may in general be free, abduction is limited. In cases where the joint is irritated, all the motions may be somewhat restricted, and if the leg is held in the position of outward rotation, flexion of the thigh will be in a plane of abduction.

Fig. 269.—Specimen from a Severe Case of Coxa Vara (Robert Jones).

In bilateral cases lordosis is present, but no shortening is necessarily detected, because both legs are involved, but both trochanters are above Nélaton's line. In bilateral cases severe limitation of abduction may rarely necessitate cross-legged progression. Some lateral curve of the spine will, of course, be present in unilateral cases, from the tilting of the pelvis incident to the shortening. The x-ray shows that the neck of the femur forms with the shaft an angle approaching a right angle, and not the normal one of from 120 degrees to 140 degrees.

Coxa vara in young children with rickets is generally not accompanied by symptoms of importance, but is masked by the bowlegs or knock-knee which coexists; until recently it has escaped observation.

Coxa vara due to destructive disease of the bone, as in arthritis deformans, osteomyelitis, and tuberculosis, is generally obscured by the symptoms of the bone disease causing it.

Traumatic Coxa Vara.—**Synonyms.**—Impacted fracture of the neck of the femur; epiphyseal disjunction. German, Schenkelhalsbrüche.

After a fall upon the hip in a child, complete or partial disability may follow immediately. If the former exists, it generally passes off in a few days, but the child is lame and has pain in the hip-joint. Motion is painful and resisted, and night-cries may be present. The clinical picture resembles closely that of early hip disease. The signs described for coxa vara will be found present, and the x-ray will show a fracture of the neck of the bone, or a partial separation of the epiphysis of the head of the bone.

Diagnosis of Coxa Vara in General.—The existence of coxa vara is to be established by the elevation of the trochanter above Nélaton's

Fig. 270.—Coxa Vara.

Fig. 271.—Coxa Vara (Joachimsthal).

line, with the fact that the head of the femur is in the acetabulum, abduction is limited, and the x-ray shows the deformity. The diagnosis may be obscured by the fact that the joint is irritated, and motion may be restricted in all directions.

The history of an accident preceding the development of symptoms would incline one to the diagnosis of traumatic coxa vara in children.

Differential Diagnosis.—**Hip Disease.**—Coxa vara is most frequently mistaken for hip disease, especially when the joint is irritated and the loss of motion involves rotation, flexion, etc., as well as abduction.

But in coxa vara the trochanter is *always* above Nélaton's line, which only occurs in advanced hip disease when the x-ray is characteristic.

Congenital dislocation of the hip at times resembles coxa vara, and in young children there may be present real difficulty in the diagnosis between the two affections. In both, the trochanter is above Nélaton's line, and in both irritability of the joint restricting motion may be present temporarily. But in the former condition the head of the femur slips around the acetabulum and does not turn in it as a center of motion, and the hip-joint is loose and unstable. An x-ray is the best means of establishing the diagnosis.

Prognosis.—There is no outlook for the occurrence of a spontaneous

Fig. 272.—Coxa Vara.

cure in coxa vara. The acute attacks can be quieted by rest, and the marked symptoms of traumatic coxa vara will diminish under fixation, but the deformity is a permanent one, and the joint can never be wholly useful because the contact of the head of the femur and the acetabulum is improper. Moreover, the direction of the neck of the femur is not sufficiently oblique to bear strain properly, and further yielding is likely. The prognosis of rachitic coxa vara in young children with severe rickets is not sufficiently formulated to know what the outlook is.

Treatment.—The object of treatment is to restore, if possible, the normal angle of the neck of the femur and the shaft. In young children and in recent traumatic cases the child should be anesthetized and the leg abducted with the use of considerable force, with the object of bending into a better line the neck of the affected femur. A plaster-of-Paris spica bandage should then be applied and worn for at least two months. After this massage and protected use (to be next described) should be followed out.

In the stage when the bone may be regarded as congested and the joint is irritable, and in cases not amenable to operation, a protection splint, described in the treatment of hip disease, should be worn for some months, to which may be added the use of crutches. In this way the strain of weight-bearing is taken off of the affected femur. This treatment is suitable for cases where the deformity is slight, in which it may be hoped that the tendency to further deformity may be checked in this way, and that the tendency to growth toward the normal direction may be enough to relieve the symptoms permanently.

If the deformity is well marked, operation may be undertaken if no complicating circumstances are present. The operation consists of subtrochanteric osteotomy, either linear or cuneiform. The former is simpler and does not shorten the leg. The rotation of the leg is corrected after the operation, and a plaster-of-Paris spica bandage applied to the abducted and corrected leg. This is worn for two months, after which a protection splint should be worn for two, at least, or three months more.

In cuneiform osteotomy the base of the wedge is outward and its apex at the level of the trochanter minor. A hinge of periosteum and bone is left at the inner side when the leg is broken.

COXA VALGA.

This name is applied to a somewhat rare condition, the reverse of coxa vara, in which the angle of the neck and shaft of the femur is increased. The reported cases have been both bilateral and unilateral. It occurs as a congenital affection, in infantile paralysis, after prolonged disuse of the leg, after amputations, and in rickets and osteomalacia; it also is found without obvious cause. But few cases have been reported, and the affection has received scant attention. The symptoms in recognized cases have been: a position of outward rotation and abduction of the leg, with limitation of the opposite movements, flattening of the trochanter, lengthening of the affected leg, pain in the hip, and a limp in walking.

The diagnosis is made by the radiograph. Two cases have been successfully operated on by Galeazzi,[49] who performed osteotomy of the neck of the femur and then restored the normal angle between head and neck by allowing the trochanter to slip upward.

CHARCOT'S JOINT DISEASE.[28]

Arthropathy—spinal, neural, neuropathic, tabetic arthropathy.

Occurrence.—The affection of the joints is said to occur in from 5 per cent. (Marie) to 10 per cent. (Lotheisen) of tabetics. It affects the lower extremities oftener than the upper (207 out of 268 cases, Chipault), and the knee much more frequently than any other joint (182 out of 441 cases, Weizsäcker and Kredel). The hip, shoulder, foot, and elbow follow in the order named.

Symptoms.—Charcot's joint disease appears as a chronic and generally destructive affection of the joints, usually affecting adults. The affection may be monarticular or polyarticular. The symptoms resemble those of arthritis deformans in a general way, and consist of swelling, effusion, loss of function, and some pain, followed, in the severer cases, by disintegration of the joint, shown by laxity and dislocation. Pain is less prominent than one would expect in so destructive a process, and sensitiveness may be slight. Ankylosis is not a common termination, the process being destructive rather than formative, and the effort at repair is slight. Suppuration may rarely occur. Although the process is, as a rule, progressive, spontaneous arrest of symptoms may occur and the joint cease to give trouble.

Diagnosis.—The affection is not always correctly diagnosticated. The existence of the symptoms of chronic joint disease in connection with organic nervous disease should be regarded as establishing a provisional diagnosis of Charcot's joint disease. The errors in diagnosis arise, as a rule, from overlooking the existence of the nervous affection or from unfamiliarity with the symptoms of Charcot's joint disease. An *x*-ray is of great value in the diagnosis.

Prognosis.—The affection tends in general to joint disintegration leading to disability, and is but little influenced by treatment.

Treatment.—The treatment consists in fixation of the joint in the acute stage, and protection by means of one of the splints described in speaking of tuberculosis of the hip, knee, and ankle, when these joints are irritable and sensitive. The protection from the traumatism of walking is frequently of apparent benefit in retarding or arresting the local process.

Resection of the joints has been performed, but the results are by no means all favorable,[29] and protective apparatus must often be worn after the operation. Amputation in the same way may or may not be followed by successful healing.

SPONDYLITIS DEFORMANS.[22, p. 214]

Synonyms.—Marie's disease; Bechterew's disease; osteo-arthritis of the spine; arthritis deformans of the spine; ankylosing inflammation; rigidity or neuropathic curvature of the spine; rigid spine. French, Spondylose rhizomélique; Kyphose hérédo-traumatique. German, Steifigkeit der Wirbelsäule.

This affection is a chronic and progressive stiffening of the spine, accompanied by pain.

Symptoms.—The first symptom noted, as a rule, is a soreness and stiffness in the back, generally diagnosticated as "lumbago." This may occur as a series of acute attacks, or begin as an insidious and gradually increasing stiffness and lameness. In the well-established affection the patient walks guardedly and moves stiffly; he stoops from the hips when bending forward, and mobility of the spine is very decidedly impaired. Some lateral deviation of the spine is present, and he can bend further to one side than to the other. The dorsal physiologic curve is increased, and the lumbar curve later obliterated so that the spine forms one convexity backward; but there is no angular projection. Pain may be inconsiderable or it may be acute. It may be felt in the spine or referred to the peripheral ends of the nerves, appearing in the chest, abdomen, pelvis, or thighs. Disturbances of sensation and reflexes and even paralysis may be present in the extremities as the result of nerve-root pressure in severe cases. The lower part of the spine is usually first affected, and the cervical part last, as a rule, but this order may be reversed and the cervical spine first involved.

Fig. 273.—Specimen from Arthritis Deformans of Spine, showing Lipping of Vertebræ (Elliott).

As the spine stiffens the articulations of the ribs and vertebral column are involved in the process, and the thorax becomes a rigid cage and the breathing becomes wholly abdominal. In the severest cases the spine is wholly rigid from the occiput to the sacrum. The course of the disease is generally chronic and covers many years, but other cases are acute.

There are two types of the affection which have at times been classed as separate diseases, although the modern tendency is to class them together. In one (the Bechterew type) the spine is generally alone affected. In the other (the Strümpell-Marie type) the shoulders and hips are also involved, and stiffen and assume deformed positions, and the disability is very greatly increased. When the latter type is present, the hips often become flexed, and the patient must walk with the trunk carried forward at an angle of 45 degrees or more, an attitude not infrequently seen in the streets. The flexion of the hips is particularly distressing because it cannot be compensated for, as in hip disease, by arching the lumbar spine.

The process in the spine may apparently be arrested in certain cases by treatment, but the tendency without treatment, and in some cases in spite of treatment, is to progress toward a stiffened condition of the vertebral column.

Diagnosis.—The diagnosis is made by the recognition of rigidity in the spine without angular prominence. Lateral deviation of the spine, increase of the dorsal physiologic curve, and the possible manifestations in other joints will in most cases establish the diagnosis. The x-ray may show the deposit of bone along the sides of the vertebræ, and perhaps atrophy of the intervertebral disks. The immobility of the thorax in inspiration is characteristic.

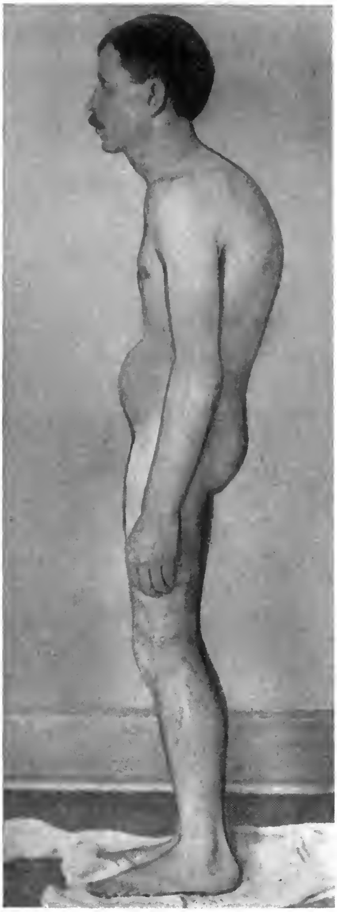

Fig. 274.—Spondylitis Deformans (Elliott).

Fig. 275.—Spondylitis Deformans (Elliott).

Differential Diagnosis.—The disease may be differentiated with difficulty from chronic sprain of the vertebræ and from certain cases of hysteric spine. In many such cases the diagnosis can be settled only by the progress of the disease, and must be withheld for a time.

From Pott's disease this condition may generally be distinguished by the fact that it most often attacks adults, that angular deformity is absent, that the x-ray shows no localized bony destruction, and that a large part of the spine is stiff and not a limited area.

Prognosis.—In moderately early cases arrest of the process and recovery with a somewhat stiffened spine are to be hoped for. In most late cases with marked deformity it may be expected to stop the pain, but a stiffened spine must result. In some cases the affection proves practically uncontrollable, and the pain goes on in spite of treatment.

Treatment.—Fixation of the spine is essential in all cases at the beginning of the treatment. A plaster-of-Paris jacket should be applied to the patient, not suspended, but standing, and worn as it is, or split and furnished with lacings. This jacket must fit snugly over the loins to give comfort, or a leather jacket may be used if desired. This apparatus should be worn until the pain has subsided and the muscular irritability has diminished. It should then be replaced by a light brace or corset to limit spinal motion. In milder cases a brace or corset may be worn from the beginning.

Massage is useful during the convalescent stage, but attempts to increase spinal motion by manipulation or gymnastics are at all times harmful.

The care of the general condition is most important, and the general health must be carefully looked after.

NEUROMIMESIS OF THE JOINTS.

Synonyms.—Hysteric joints; functional affections of the joints; neuromimetic joints. German, Gelenkneurose. Italian, isteria mimetica—neuromimesi.

The terms above given are applied to those affections of the joints in which the subjective symptoms are out of proportion to the objective signs. As our knowledge of joint disease increases fewer affections of this sort are classed as hysteric because objective signs are more carefully studied, and are recognized in slighter grades than was formerly the case. For example, many cases of knee-joint disease which at one time would have been classed as hysteric, would now be considered as slight grades of arthritis deformans, as due to muscular laxity, as the result of hypertrophied fringes, as due to flat-foot, etc.

Functional joint affections occur most often in young women, and generally in persons of an emotional type. Children are not often affected, but in later childhood typical cases may be seen. *Trauma* is the most frequent antecedent, and in medico-legal cases, where damages are being claimed, the affection is seen in its typical forms. The combination of trauma and self-concentration, with or without a desire to exaggerate symptoms, is familiar to every practitioner. *Overstrain,* although closely allied to trauma as a cause, is induced by excessive demands on the nervous or muscular system induced by illness, overwork, rapid growth, and similar causes. An *emotional or hysteric temperament* is a powerful predisposing cause. *Errors in refraction, uterine disorders,* and *sexual irritation* are factors to be borne in mind.

Symptoms.—The symptoms of the various types of joint disease are likely to be simulated by functional disease. Pain is most frequent and is generally excessive; as a rule, it is worse some hours after the use of the joint. Sensitiveness is always marked, and is in a measure due to hyperesthesia of the skin. Muscular spasm may be present, but is not constant and unvarying, as in true joint disease, and is in large part voluntary and not due to reflex muscular spasm.

Muscular atrophy and positions of deformity similar to those of true joint disease may be observed, and swelling of the affected joint has been described. Disturbances of circulation may exist about the affected joint, resulting in variations of the local temperature, and in affections of the joints of the lower extremity lameness is likely to be pronounced or excessive. The stigmata of hysteria may be present.

Diagnosis.—The diagnosis, as a rule, offers much difficulty and must be made with very great care, for without a diagnosis of which one feels sure no progress can be made in treatment. The symptoms are out of proportion to the local objective signs, and are grouped in an anomalous way.

Hyperesthetic areas and the stigmata of hysteria are suggestive signs. Much information may be gained by watching the involuntary movements of the patient, who will often in this way move a joint freely that is held stiffly when manipulation is attempted. The best results in diagnosis are reached by a process of exclusion.

The *x*-ray is of great value in this connection. It is a matter of record that tuberculous joint disease and the like is not uncommonly diagnosticated as hysteria and vice versâ, a mistake which is most often due to incomplete and hasty examination.

Prognosis.—The outlook in these conditions depends in a measure on the duration of the affection, the age and mental makeup of the patient, the accompanying degree of nervous disturbance, and the skill with which they are treated. In general, uncomplicated cases do well, and the outlook for improvement and cure is favorable unless the affection has been of long duration.

Treatment.—A sound diagnosis is essential to successful treatment, for the same measures are not suitable for both functional and organic disease, and temporizing is a bar to a successful issue.

The general condition should be brought to as near normal as possible. The local condition is to be regarded as due to an abnormal state of the circulation and innervation of the affected joint. It is wise to explain this to the patient, for the statement that nothing is the matter or that it requires only an effort of the will to overcome it will not be accepted by the patient, and her confidence and coöperation are essential.

Any distortions that exist in the affected limb should be corrected, preferably under anesthesia. The gradual use of the limb should then be begun, and this use progressively increased without regard to the pain caused by it. In serious cases it is generally advisable to assist the limb temporarily in its early use by crutches or by some protective appliance, as by a protection hip-splint in hip or knee affections. Along with this progressive increase in use should go measures to stimulate the local circulation and to improve the muscular condition of the affected joint. Hot-air baths, douches, electric stimulation, passive exercises, vibratory massage, and massage with the hands are the most available remedies at our disposal. Counterirritation and especially cauterization are undesirable, as they emphasize the gravity of the local condition too much in the patient's mind, and are not in line with the main object of the treatment, which consists in progressive use, disregard of painful sensations, and measures to regulate the local circulation. Patients with hysteric joints must be absolutely under the surgeon's control, and, as a rule, are better treated away from home when the condition is of any severity.

The Neurasthenic Spine.—**Synonyms.**—Functional affection of the spine; irritable spine; hysteric spine; and, sometimes, chronic sprain of the spine.

The name neurasthenic spine will be used here to designate those painful affections of the spine in which the subjective symptoms are out of proportion to the objective signs, and in which no organic disease can be found to exist.

The **symptoms** of the condition vary very much in severity, but comparatively little in type. The slightest grade is shown by backache, increased by exertion and physical or mental fatigue. Sensitive spots may be present near the spinous processes in different regions of the spine. Sensitiveness of the skin and certain muscles may be present. The pain is increased by motion and jar, and, as a rule, persists for many hours after the cause of it has stopped.

The severest type is represented by a condition in which the patient is unable to sit erect on account of similar symptoms of severe grade. Between the two extremes lie cases of every degree of severity. In the severe cases of long standing some impairment of motion is likely to come on, and lateral deviation of the spine to a slight degree may be present. In most cases, especially in the severer ones, the patients present some of the general symptoms, which would be classified as neurasthenic or hysteric. The condition is almost invariably chronic, and without treatment its tendency is to remain stationary or to grow worse.

The prolonged maintenance of a faulty attitude may induce in the spine irritability and pain, presumably from ligamentous and muscular strain and consequent irritation.

A factor causing faulty attitude in some cases is to be found in an inequality in the length of the legs, by reason of which the pelvis becomes oblique and a slight degree of lateral curve in the spine is necessarily induced.

A condition of functional irritability of the spine is caused at times by the existence of flat-foot and contracted foot.

Some cases result from severe traumatism, serious and violent accidents, which are followed by stiffness, disability, and, perhaps, lateral deviation. These cases may be spoken of as chronic sprain of the spine.

This condition, apparently, may exist unimproved for months or years, and in its later stages it is sometimes almost impossible in some cases to differentiate it from organic disease of the spine. In the same way such cases may simulate Pott's disease, and a prolonged observation is necessary before a diagnosis can be made.

In some cases the cause appears to be a slight traumatism, such as a misstep, a slight fall, the sudden starting of a carriage, a stroke in golf, or some similar accident. It seems merely a slighter grade of chronic sprain, as just described, with less objective basis and more subjective symptoms. The connection with the injury is probably at times a fanciful one, and the neurasthenic element is likely to be pronounced.

In some cases severe spinal disability occurs without traumatism or obvious faulty attitude in connection with severe grades of neurasthenia. They may be, perhaps, best spoken of under the unsatisfactory name of spinal invalidism.

Treatment.—In those cases in which strain seems to be due to faulty attitude it is obvious that the first requisite of treatment must lie in correcting such attitudes and restoring the spine, so far as possible, to its normal position and proper balance by proper gymnastics or braces if necessary.

Exercises must be used with great moderation at first, as they prove, as a rule, tiring and most often at first aggravate the pain and irritability. If the spine curves to one side, owing to the shortness of one leg, it is essential that the boot of the shorter side should be built up to compensate. If flat-foot is present, it should be corrected.

Along with exercises and support should go measures to stimulate the local circulation, such as massage, douches, and baths. Equally essential is the avoidance of fatigue; recumbency for part of the day is important.

In cases of sprain due to severe injury, the earlier the case is efficiently treated, the better. Simple recumbency is not enough, but in the early stages recumbency of the patient on the back, secured to a gas-pipe rectangular frame or wearing a plaster jacket, is the best treatment. If the patient has been going about, as most of them have been, in a partly disabled condition, with a stiff, sore, and irritable back, the application of a plaster jacket is indicated. This should be worn for some time, and discontinued very gradually as massage, douches, and exercises for restoring flexibility are begun. The convalescence of such patients is discouragingly slow, and exercises must be used with great caution and not during the irritable stage.

In the cases of chronic sprain due to slight traumatism a brace or corset may be temporarily of use in steadying the spine and limiting movement. In this class of cases, however, massage, douches, and hot air are most likely to be of use. Plaster jackets are not often necessary in these cases.

ARTICULAR NEURALGIA.

Primary articular neuralgia in adults may exist as a fleeting and unimportant affection, but should not be considered a satisfactory diagnosis for anything of a more permanent character. As pain is the one symptom common to practically all affections of the joints, it is safe to investigate its cause with very great care.

What is probably epiphyseal hyperemia and irritation occurs at times in children, often traumatic in origin, and is expressed by pain and sensitiveness, and perhaps temporary lameness in the neighborhood of a rapidly growing epiphyseal line. It is seen in its clearest form at the heel, it exists in the knee and hip, and probably in other joints.

The joint is sensitive and aches after use for a little while, and in severe cases the irritability may last for weeks or months. There are no signs of joint disease, the *x*-rays show normal structures, muscular atrophy is absent or slight, and the only symptoms are a temporary or intermittent lameness and pain. The treatment consists in rest.

JOINT DISEASE IN HEMOPHILIA (BLEEDER'S JOINTS).[48]

The joint disease seen in hemophilia affects most often the knee, and resembles tuberculosis clinically, as it occurs most often in children. It may be single or multiple, and is characterized by swelling, heat, pain, tenderness, and loss of function. With succeeding attacks motion of the joint is diminished, and use is accompanied by aggravation of symptoms. After a blow or in connection with the effusions an extensive ecchymosis may become evident.

FIG. 276.—BLEEDER'S JOINT (HEMOPHILIA).

Diagnosis.—From the fact that several fatal hemorrhages have been recorded as the result of attempting to excise these joints under the impression that they were tuberculous, it is evident that the diagnosis is not always easy. They simulate mild tuberculosis almost perfectly, but the *x*-ray will show that the bone is not involved, and that the process is confined to the soft parts of the joint.

The **prognosis** is bad and points to a progressive increase of a disabling affection.

No satisfactory **treatment** has been formulated. Fixation is indicated during acute attacks, and protection of the joint from weight-bearing seems to be of value in retarding the progress of the disease.

SYPHILIS OF THE JOINTS.

(See Vol. I, p. 709.)

WOUNDS OF JOINTS.

Penetrating Wounds.—A wound penetrating a joint derives its gravity not from the injury inflicted to the joint, but from the very great likelihood of infection. Obscurity arises chiefly in the case of accidents where a skin wound is found over a synovial cavity, and the question is whether the wound has penetrated the synovial membrane or not. The escape of a sticky, transparent fluid like the white of an egg establishes the fact that the joint has been penetrated. If such a history cannot be obtained and the wound is apparently superficial, the surgeon must be guided by his judgment and the circumstances of the accident as to whether or not the joint has probably been opened. The subject is confused by the fact that in such cases, after a few hours, a slight cellulitis of the overlying structures is likely to occur, thus obscuring the whole matter.

The indications for considering that the joint has been opened are the escape of fluid and the appearance of a synovial effusion in the joint. The presence of a burning sensation in the entire joint and stiffness are suggestive, but not convincing. The occurrence of pain and effusion are indications that the joint has become infected.

A penetrating wound is, however, not necessarily an infecting wound, because clinical experience shows that punctured wounds inflicted by small, sharp-pointed bodies frequently do not cause joint infection, although they may enter the joint, the bacteria in these cases probably being wiped off by the skin.

The **treatment** in these cases is to disinfect the skin wound with all possible care, enlarging it, if necessary, to reach it thoroughly. It should then be dressed antiseptically and the joint put at rest. If effusion to any considerable degree follows, the joint must be assumed to be infected and prompt treatment must follow (see Infected Wounds).

Aseptic Wounds.—Aseptic wounds of the joints are not likely to occur except in operative procedures, in small punctured wounds, and in gunshot wounds, and no wound received otherwise can be assumed to be of this character. The danger of joint infection in operations, when all precautions have presumably been taken, is known to all surgeons, and is a suggestive comment upon the vulnerability of joints to infectious organisms.

Infected Wounds.—The infection of a joint demands most vigorous and prompt measures, for the infection of a synovial cavity is followed by immediate reaction, with the pouring out, into the joint, of synovial fluid which rapidly becomes purulent and threatens not only the usefulness of the joint and limb, but at times the life of the patient. Infected wounds should be promptly recognized and treated by radical measures. The joint should be immediately opened by a free incision. Small incisions are inefficient and, as a rule, repented of later; a long incision heals as rapidly as a short one, and inflicts practically no more injury to the joint. Having exposed the joint freely, it should be thoroughly flushed out with 1 : 10,000 corrosive solution, followed by sterile salt solution, an attempt being made to distend the joint by the fluid and to wash out all parts of it. This flushing cannot be too thorough and should be repeated again and again. The joint should then be drained by a tube or a wick of gauze and placed at rest. If symptoms of joint inflammation persist, the joint should again be flushed at the end of twenty-four hours, and the drainage continued. If, at the end of two or three days, the symptoms of joint inflammation have subsided, the drain may be removed and the joint allowed to close.

In cases of penetrating wounds where infection is doubtful, after the joint has been opened and flushed, it is wise to insert provisional sutures, which may be tightened at the end of twenty-four or forty-eight hours if no symptoms of joint irritation have then appeared.

Subsequent incisions should not be necessary if the joint, in the first place, has been opened satisfactorily, except in severe cases, when it may be advisable to incise the joint at every available point in order to secure free drainage. If the joint becomes thoroughly infected or is thoroughly infected at the time of operation, nothing can be done except to drain with all possible freedom, to keep the joint at rest, and to resort to continuous irrigation or repeated flushing, in these cases using weak germicidal solutions (1 : 10,000 corrosive solution) instead of salt solution.

The knee-joint deserves special mention on account of its frequent injury, its great liability to infection, and the extensive distribution of its synovial membrane. In cases where infection is only suspected and not established, one incision, two or three inches long, at the seat of the injury should be regarded as sufficient. If infection, however, exists, an incision of this length should be made both on the inside and outside of the patella and the joint thoroughly flushed and drained.

Gunshot Wounds of Joints.—See chapter on Military Surgery.

SPRAINS.

The name sprain is somewhat loosely applied to a certain class of joint injuries which present the same general characteristics, but which differ somewhat according to the especial joint structure most affected. One may thus recognize the existence of one or more of four types of injury. First, where the synovial membrane is chiefly affected; second, where the ligaments are the parts most injured; third, where the tendons about the joint are the chief seat of inflammation, and, fourth, where a contusion over the joint is the main cause of the symptoms. Any one of these types or any combination of them may be found in a given case. (See chapter on Fractures.)

Symptoms.—The symptoms consist of severe pain at the time of the injury, which is generally caused by a force moving the joint beyond its normal limit of motion. This pain caused by the injury is followed by a swelling, stiffness, and often a painful condition of the injured joint, but at times pain is not a prominent symptom, and is only to be elicited by pressure or manipulation of the joint. Ecchymosis is present in most cases and may be extensive. Tenderness is present and is most marked over the injured structure, and is of great value in determining what part of the joint has been chiefly affected. Function is impaired and use is painful. Under favorable conditions the symptoms slowly subside, swelling and tenderness and impairment of function lasting longest, and after a period varying from a few days to several weeks the joint returns to its normal condition.

Chronic Sprains.—In healthy persons sprains not infrequently fail to pursue the course described above and become chronic. Such cases, as a rule, fall into one of two classes. In one, the acute synovitis has not been recovered from on account of misuse or too early use of the joint; and in the second, which is comparatively less common, the muscular weakness (which is always the accompaniment of sprains) may persist, and later be of itself a cause of joint symptoms. In either case the disability may be classed as chronic sprain.

In chronic sprains of the larger joints in healthy persons the chief characteristics are long duration without improvement, excessive sensitiveness and irritability, swelling, stiffness, and muscular wasting. Fixation is often avoided by the surgeon for fear that the joints may become permanently stiff, and the patient goes on changing from one treatment to another for months. In a second class of chronic sprains in healthy persons persistent muscular weakness resulting from the original joint trouble may lead to a condition of pain and partial disability of the joint after the joint affection proper has recovered.

Sprains are likely to become chronic and to lead to disabled joints in neurasthenia, arthritis deformans, tuberculosis, and locomotor ataxia.

Diagnosis.—The practical importance of a careful discrimination of acute sprains from fractures is self-evident, yet fractures are continually overlooked and diagnosticated as sprains. The only safe rule is to insist on an ether examination or a radiogram in all cases of sprains of more than slight degree, and in cases of even slight degree to examine with extreme care and to secure a radiogram.[23]

Chronic sprains resemble tuberculosis and arthritis deformans, and the diagnosis will frequently be difficult.

Prognosis.—Acute sprains in healthy individuals under efficient treatment should wholly recover in a period varying from one or two weeks to one or two months. Ligamentous injuries last longer than the other forms, as a rule. The presence of neurasthenia makes a long course likely, and a chronic sprain is often to be avoided only by most careful treatment in neurasthenics. Sprains in tuberculous patients may be followed by tuberculosis of the joint or may recover as in normal persons. In patients with arthritis deformans and locomotor ataxia sprains generally recover slowly and often leave behind them more or less permanent impairment of the affected joint.

Treatment.—Two forms of treatment are recognized as efficient. In the first the treatment described for traumatic synovitis is carried out. In the second method measures to stimulate the local circulation are begun at once, while the joint is used moderately. The method is painful, and in severe sprains is better suited to athletes with strong muscles than to women. So soon as possible after the injury the joint is baked in a hot-air oven and massaged for a few minutes or massaged without baking. Massage or baking, or both alternately, are then used daily for two periods of half an hour each. The joint is supported by a bandage and moderate use is encouraged. The massage periods are gradually separated by a longer interval, and alternating douches of hot and cold water added. The vigor of the treatment is gradually diminished as the condition improves. Vibratory massage is of use.

The treatment by rest is in general more suitable for very severe sprains, in the case of children and neurasthenics and in cases where arthritis deformans of any degree is present. The treatment by early massage is most generally useful in moderate and slight sprains without complications occurring in vigorous persons. The circumstances of the patient will often be the determining factor in the selection of the treatment.

FIG. 277.—STRAPPING FOR SPRAIN OF THE ANKLE.

Treatment of Chronic Sprains.—The routine of treatment which is of most service seems to consist of complete rest and fixation of the joint, at first until the irritation of constant use has been partly recovered from. In slighter cases restricted use is enough. In connection with this a daily local bath of hot air is of the greatest value. As soon as the excessive irritation has subsided, massage, at first of the gentle sort, and later of a much deeper character, is indicated, not only to the joint, but to the whole limb. If the limb is held in malposition, that malposition must be corrected and limited, but increasing use of the limb must be begun and persisted in. Other measures which are of use in restoring the circulation besides hot air, proper use, and massage are alternating hot and cold douches, electricity, and liniments where massage is not available.

Sprains of the Ankle.—On account of its flexibility and constant use in weight-bearing the ankle is the joint most frequently sprained. The anatomic location of the injury is generally easily determined on account of the accessibility of the joint. The symptoms described above are found to exist, accompanied by lameness or inability to walk at all.

Swelling is most extensive on account of the dependent position of the joint, and is a marked feature in most cases.

The treatment by massage and stimulating measures from the outset is particularly applicable in the ankle.

For walking the ankle is efficiently supported by adhesive-plaster strapping applied as follows: Overlapping straps half an inch wide and about twelve inches long are applied to the foot with the sole inverted. The first strap starts at the outer border of the foot, near the little toe, and passes horizontally around the back of the heel, ending on the inner side of the foot about its middle. The second strap is applied vertically and passes from the lower part of the calf of the leg down alongside the tendo Achillis, under the heel, and terminates above and behind the malleolus. The third and fourth straps are similarly applied, a little above and overlapping by about one-half the first and second straps respectively until the whole ankle is covered in, as shown in Fig. 277. Additional straps may be applied over the malleoli and the tendo Achillis. This treatment was first suggested by Cotterell, of London, and has been popularized in America by Gibney. Modifications of the manner of strapping may be made to suit any special indication.

Chronic sprain of the ankle is frequently seen. Apart from the cases where the chronic sprain is associated with or caused by flat-foot the treatment does not differ from that described for chronic sprains in general, except that a shortened gastrocnemius is generally a complicating factor. In such cases the muscle must be lengthened by stretching, as described under Flat-foot.

Knee.—On account of the strength of the ligaments of the knee, sprains of that joint are almost invariably expressed as synovitis. Ligamentous injury may be a complicating factor.

Hip.—Sprains of the hip are manifested clinically as synovitis.

Wrist.—On account of its great mobility the wrist-joint is, like the ankle, very frequently sprained. The anatomic character of the injury is easily made out on account of the accessibility of the joint, and inflammation of the tendons in connection with the injury is more common than in any other joint, the sprains frequently being almost wholly tenosynovitis of one or more tendons. The frequency with which Colles' fracture is diagnosticated as sprain needs only to be mentioned.

On account of the constant temptation to use the wrist-joint fixation is advisable, even if massage is used from the outset.

Elbow.—Sprains of the elbow-joint are infrequent and, as a rule, are manifested clinically as synovitis. Chronic sprain of the elbow-joint exists in the form known as tennis-elbow, which is frequently an injury to the internal lateral ligament. A similar condition is seen in golf-players and baseball pitchers.

Shoulder.—Sprains of the shoulder-joint are somewhat peculiar in character and frequently most troublesome. After an injury to the joint the symptoms may be comparatively slight at first, consisting of stiffness and pain in certain motions. These may increase in severity and the joint become stiff and painful, or it may remain movable but continues painful in the execution of certain motions. The affection is not easy to differentiate anatomically, but may be recognized as a synovitis, a tenosynovitis, an irritability of the capsular ligament, or as a bursitis. The involvement of certain muscles is recognized by the pain incurred in the motions involving them and in the location of the tenderness.

The diagnosis from peri-arthritis, also generally of traumatic origin, is often made with difficulty, and no definite diagnostic signs can be given beyond those afforded by a knowledge of the anatomic structures.

Prognosis.—The prognosis is, of course, favorable, but the course is slow and many cases are already chronic when first seen.

Treatment.—The usual treatment is aided by the use of a sling supporting the tip of the elbow and preventing the dragging of the weight of the arm on the capsular ligament.

Sacro-iliac Joint.—The sacro-iliac synchondrosis is capable of some motion in addition to its function of weight transmission.[54]

Acute sprains of this articulation are to be seen sometimes after severe accidents and wrenching the spine and pelvis, and are manifested by tenderness over the joint and pain in this location in walking, rising from a sitting position, and similar motions.

A condition of chronic sprain or irritability, rather than the acute sprain, is, however, more common in these joints. It is more common in women than in men, and is more often unilateral than bilateral; it occurs more often in persons of lax muscles than in well-developed people, and it is especially frequent in patients of neurasthenic tendencies; it follows at times the relaxation of these joints normal in pregnancy. Strain of these joints is induced by faulty attitude, such as the common one assumed by feeble women of standing with the pelvis thrown forward and leaning back from the waist, and a short leg is also a common source of trouble in one joint by bringing more weight on one joint than on the other. Pain on pressure over the joint, backache, especially unilateral, and discomfort in the region in walking and standing are characteristic signs.

Treatment.—The acute and severest chronic cases are to be treated at first by plaster-of-Paris jackets applied tightly around the hips, pelvis, and sacrum, and afterward by corsets. Cases of average severity are best treated by corsets of elastic or leather, which support the lumbar region. In still other cases a steel pad fitting down over the sacrum and attached to straps passing around the pelvis or embodied in a molded leather girdle is of value.

Sprains of the Vertebræ.—Acute Sprains.—Sprains of the vertebral column occur just as in other joints, but on account of the peculiar structure and function of the spine, the symptoms of them are somewhat modified and peculiar. Injuries to the vertebral column are not generally classified frankly as sprains, but as contusions, muscular injuries, wrenches of the spine, etc. It would be better if this class of injuries were brought into general terminology and classed as sprains, remembering that the term includes either synovial, muscular, or ligamentous lesions. The subject is considered in connection with the Hysterical Spine.[62]

Sprains of the Temporomandibular Joint.—In certain cases, particularly in women with lax muscles, the joint connecting the lower jaw with the skull becomes sprained. This condition exists more in the form of a chronic irritability than as an acute sprain. Opening the mouth is painful, chewing is attended with pain in front of the ear, and the pain sometimes continues when the joint is at rest. It is not infrequently seen in connection with slight degrees of arthritis deformans, and may become a troublesome complication. Tenderness exists below the zygoma, outside and inside of the mouth over the inner aspect of the joint.

The prognosis is favorable except in cases of marked arthritis deformans.

The treatment is complicated by the inaccessibility of the joint. The use of the joint in chewing must be largely given up, and the patient live for some days on soft food; yawning is to be avoided, and some cases are so acute that even talking is a source of irritation. Patients of intelligence can be trusted to take perfectly good care of the joint without the use of bandages or splints, with instructions not to open the mouth wide for any purpose, and massage is of great value. It should be applied not only over the outer surface of the joint through the skin, but the finger should be protected by a rubber cot and the joint thoroughly massaged through the mouth, where it is easily accessible at its inner aspect. Although the use of blisters over the joint on the outside in some cases seems to give relief, they prevent massage and are therefore to be avoided.

TREATMENT OF ANKYLOSIS.

If the ankylosis is bony, treatment short of operation is obviously useless. Much information may be obtained from a carefully taken radiograph as to the presence of bony ankylosis. Cartilage shows as a clear space between the articular ends of the bones, by which they appear to be separated in the radiograph.

When there is reason to believe that the ankylosis is not bony, an attempt may be made to stretch or break the adhesions and thus to increase the range of motion. The measures in use are as follows:

(*a*) **Manual Stretching.**—The patient is not anesthetized and the joint is gently but forcibly moved first in one direction and then in another to the limit of pretty severe pain. Adhesions may be felt to yield during this process. The joints should then be *kept quiet* for some hours, and the process repeated on the following day. If too much force is used, inflammatory reaction will be excited and the aim of the treatment defeated, and the same end is brought about by continual nagging efforts on the part of the patient and his friends to move the joint again every hour or two.

Mechanic Stretching.—The rhythmic swing of a pendulum may be utilized in the construction of forms of apparatus in which the joint is alternately flexed and extended by the swinging of the pendulum, which swing is gradually increased during the treatment. Other forms of apparatus rely on elastic pull and the action of weights. The Zander apparatus is adapted to the mechanic stretching of ankylosed joints.

Forcible Stretching.—If these measures prove ineffectual, if the case is of long standing or the patient very apprehensive, or if it is desired to obtain a thorough examination to determine the extent of the ankylosis, the patient should be anesthetized and the joint moved by a reasonable degree of force, which must in every case depend on the surgeon's judgment. Roughness excites inflammation and causes new adhesions and is to be avoided. Following this manipulation the joint is fixed for from one to two days and the process repeated, or one of the other forms of stretching substituted.

Local Measures.—Accompanying any of these forms of treatment an attempt should be made to regulate the local circulation by massage, douches, hot-air baths, Bier's congestive treatment, or vibratory massage used daily.

Operative Treatment.—If the ankylosis is bony, one of the following measures must be adopted:

Osteotomy is of use for the correction of vicious position, and although it does not restore movement to the joint, it can restore a proper position. It is preferably linear when possible, because removal of a wedge-shaped portion by osteotomy invariably shortens the limb. The section is generally made just above or just below the articular surface.

Excision of an ankylosed joint may be performed not with a view of restoring motion, but of improving position, the ends of the bones being cut in such planes as to give the desired position of the joint when they are placed in contact.

Formation of Movable Joints.—Arthroplasty.—Experiments and operations covering a period of many years as to the restoration of motion in stiffened joints have demonstrated that the restoration of more or less motion is frequently possible by the interposition of aponeurosis and fatty tissue between the divided ends of the bones originally forming the articulation. Interposition of animal membrane, such as pieces of bladder, and of plates of celluloid, silver, tin, rubber, magnesium foil, etc., has been performed with varying results, but the best results have been obtained by the interposition of the soft tissues.

Fatty tissue is the most available for this use because fat tissue under pressure forms a bursa or hygroma and readily develops connective tissue as well. This fact has been utilized by Murphy [65] and others [20] in formulating an operation attended by brilliant results.

The technic is as follows: the bones forming the joint are chiseled apart as nearly as practicable in the plane of the articulation, and prominences of bone liable to limit motion are removed. The synovial membrane and capsule are then extirpated, and with them cicatrices and any other structure which will limit motion. Muscular attachments alone are to be left, and if muscles are shortened, they must be elongated.

The thorough removal of these soft parts is of primary importance. A flap of muscular aponeurosis covered by fat, large enough to cover the

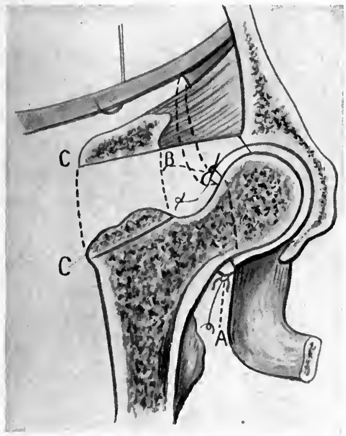

Fig. 278.—Great Trochanter (C) with its Attached Muscles Turned Upward.
The fascial flap surrounds the head of the femur and is sutured to the capsule at A and B (Murphy).

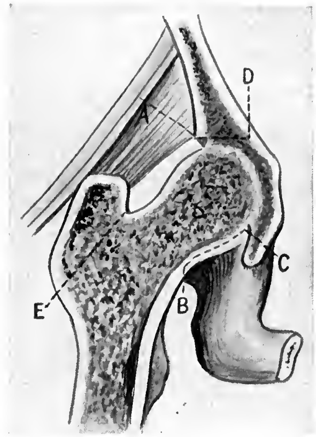

Fig. 279.—Showing Bony Union Between Head of Femur and Acetabulum.
In separating the bones the chisel was entered at points C and D (Murphy).

ends of the bones, is then freed in the neighborhood of the joint and turned in between the bones and stitched to the edge of the capsule which has been left. If aponeurosis is not available, a muscular flap with as much adherent fat as possible is used. The skin wound is then closed and the joint fixed for a week or more. In the second week passive motion and massage are instituted, the former under anesthesia if necessary, and in spite of pain passive motion must be kept up, as the formation of a joint depends upon the transformation of the interposed tissue to a bursa, and prolonged fixation simply leads to the formation of a new cicatrix.

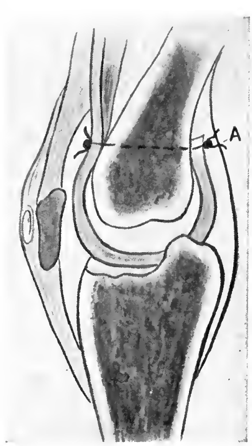

Fig. 280.—Sagittal Section Through Knee-Joint.
Showing entire articular surface of femur covered by fascial flap, which is sutured to periosteum at A (Murphy).

LOOSE BODIES IN JOINTS.

Synonyms.—Joint mice; loose cartilages; rice bodies; floating or movable bodies, etc.

This name applies to movable, free or partly free bodies formed in the joints and acting as a source of irritation. In most cases they appear in the knee, but occasionally in other joints.

Symptoms.—The most constant symptom in all cases is some degree of chronic synovitis, the characters of which have been described. The peculiar symptom caused by the loose body is a catching of the joint in a position of flexion and the inability of the patient to extend the joint until the loose body has been slipped from between the articulating surfaces. These "catches" may be very severe and accompanied by nausea, faintness, and sickening pain. (See chapter on Muscles and Tendons, p. 451.)

What has been said applies chiefly to the cartilaginous or fibrous bodies, which are generally of comparatively small size, and, as a rule, can be detected under the skin as small slippery bodies of varying shape. They are most often found in front of the external or internal condyle or at the inner side of the patella. Sometimes they cannot be detected from the outside. Exceptionally, they may be identified in the *x*-ray negative.

Lipoma of the Joints.—This form of foreign body is most often found in the knee-joint. Recurrent chronic synovitis of greater or less degree is present, the joint is irritable, and function is imperfect. "Catches" may be present, but are not generally severe. The fatty tumor is identified as a dense swelling, most often at the side of the patellar tendon.

It is important to differentiate between the different varieties of loose bodies commonly found in the joints. This has been discussed in speaking of chronic synovitis. The diagnosis from dislocation of the semilunar cartilages is discussed in the same place.

Prognosis.—Without operation there is no prospect of recovery.

Treatment.—If a foreign body can be identified from the outside, it should be transfixed with a needle thrust through the skin, cut down on, and removed, the joint being carefully examined for the presence of others.

After the removal of the foreign body the joint should be closed by sutures without irrigation, unless a large amount of bleeding has occurred, and fixed for two to three weeks, passive motion being begun in a few days.

Lipoma of the joint is removed by a longitudinal incision at the side of the patella, exposing the mass, which is removed with scissors and the joint closed.

DISLOCATION OF THE SEMILUNAR CARTILAGES OF THE KNEE-JOINT.

Hey's Internal Derangement of the Knee-joint; Slipping Cartilage; Loose Cartilage.

This condition, which is found mostly in young adults and oftenest in men, is fairly frequent.[47]

The original injury generally comes during tennis-playing, dancing, or jumping, when the tibia is rotated outward on the femur with the knee slightly flexed. Sometimes it occurs from a severe wrench, as in football, and sometimes from very slight misstep or a sudden turn in standing or walking. A sickening pain is felt in the knee, and it is impossible to extend it. Some protrusion of one of the cartilages, generally the internal, may be felt at the front of the joint. Reduction is effected by flexing the knee, rotating the tibia, and pressing back on the cartilage. Following the injury there is a synovitis accompanied by tenderness over the front of the cartilage on pressure. In many cases the attack is repeated during some slight twist of the knee. The joint becomes irritable, chronic synovitis is present, and in the older cases

Fig. 281.—Lower Part of Right Capsule Hardened in Formalin.
Femur removed, showing semilunar cartilages and crucial ligaments (Tenney).

marked muscular atrophy and joint relaxation, so that lateral movement of the joint is present.

The **prognosis** after the first attack is doubtful; recurrences may or

Fig. 282.—Semilunars of Right Knee, Showing Effects of Long-continued Friction (Tenney).

may not occur. After subsequent attacks others are likely to follow, and there is little outlook for spontaneous recovery.

Treatment.—The original attack should be treated as an ordinary acute synovitis, except that use of the leg should be resumed with care and especial attention given to massage. The tendency of the cartilage to slip is diminished by building up the inner side of the sole and heel of the boot $\frac{1}{8}$ or $\frac{1}{4}$ of an inch, so that the foot is thrown more on to its outer border.

After the repetition of the attacks some further measures are necessary. Mechanic treatment by means of knee-caps, bandages, pads over the cartilage, etc., is rarely efficient, promotes muscular atrophy, and is a source of discomfort. An efficient splint has been devised by

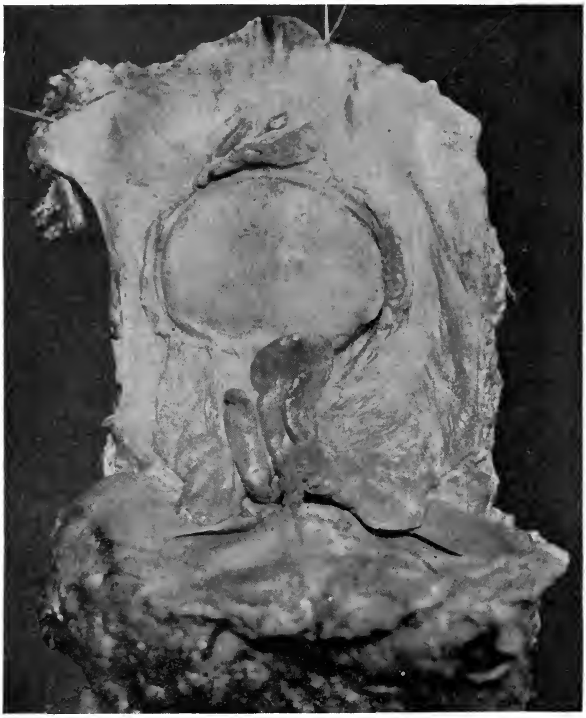

Fig. 283.—Infrapatellar Pad, Showing Tabs, Left Knee (Tenney).

Shaffer[47] which prevents full extension of the knee, side motion, and rotation. This splint, if worn for a period of many months, is likely to produce a union of the cartilage if it is not too seriously injured in the first place.

The operative treatment is, however, as a rule, quicker, surer, and more acceptable to the patient. With strictest asepsis the joint is opened by a longitudinal incision over the displaced cartilage, the loose part of the cartilage removed, and the joint closed by sutures. Fixation for two or three weeks should follow, after which massage and passive manipulation are begun.

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CHAPTER XXVI.

DISLOCATIONS.

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A *dislocation* is a displacement from each other of the articular ends of the bones which enter into the formation of a joint.

A *compound or open dislocation* is one in which there is a communication between the external air and the cavity of the dislocated joint.

A *complicated dislocation* is one in which there is either a coexisting fracture of one of the bones forming the joint or an injury of the adjacent vessels or nerves.

A *multiple dislocation* is one in which there is a simultaneous displacement in the relation of the bones composing two or more joints of the body.

Dislocations may be divided into complete and incomplete, according to the degree of displacement.

A *complete dislocation* is one in which the articular surfaces do not touch each other at all or only by their edges.

An *incomplete dislocation* or subluxation is one in which there is only a partial separation or displacement of the articular surfaces forming a joint.

Dislocations are divided according to their causes into traumatic, pathologic, and congenital.

A *traumatic dislocation* is one in which a normal joint is suddenly dislocated as the result of external violence or of muscular action. A *pathologic dislocation* occurs only after marked changes in the joint surfaces or an abnormal distention of the joint capsule as the result of disease.

A *congenital dislocation* is one which occurs during intra-uterine life as the result of errors in development or of a displacement *in utero*.

The nomenclature of dislocations is somewhat misleading. The name given to the dislocation of any particular joint is usually that of the distal bone of the articulation. A dislocation of the shoulder-joint is called a dislocation of the upper end of the humerus. When one speaks of a dislocation of the elbow, it always refers to a dislocation of both bones of the forearm. If either of the latter is dislocated alone, the injury receives its name from the dislocated bone.

Etiology and Mechanism of Traumatic Dislocations.—Predisposing Causes.—1. *Anatomic peculiarities* which favor dislocation. In certain joints, especially those of the ball-and-socket variety, favorable conditions for the occurrence of displacement of their articular surfaces exist. Dislocations occur more frequently in the shoulder-joint than in any other joint of the body, owing to the relatively large size of the head of the humerus and the small size and shallowness of the glenoid cavity. Dislocations are also favored by a loose capsule and weak ligaments around a joint, conditions which are present in the shoulder-joint. 2. *Age.* Traumatic dislocations are very rare in children below the age of ten. The largest number occur during middle life. Dislocation of the shoulder is very rare before the age of twenty-one, while dislocation of the elbow is quite common. Of 1234 traumatic dislocations reported by Stimson[1] as occurring in the Hudson Street Hospital for ten years, over 90 per cent. were of the upper extremity. Undoubtedly the greater frequency of falls upon the outstretched hand favors the production of dislocations of the upper extremity.

Exciting Causes.—A dislocation may occur as the result of—(*a*) indirect violence; (*b*) direct violence; or (*c*) muscular action.

(*a*) *Indirect Violence.*—This is the most frequent cause, the force being applied at a distance from the joint. The mechanism in dislocations by indirect violence is as follows: After a fall, for example, upon the outstretched hand with the arm rigid and abducted, the head of the humerus is carried beyond its utmost limit of physiologic excursion, and either the head or neck is arrested by the edge of the glenoid cavity, which acts as a fulcrum. The long arm of the lever corresponds to the shaft, and the short arm to the head. The force continues to act at the end of the long end of the lever and the head is thus forced away from the glenoid cavity. Dislocations of the other joints from indirect violence are produced in a similar manner. The capsule, after stretching to its utmost, yields, and the head of the bone escapes through the tear, the further position being determined to a great extent by muscular and ligamentous action.

(*b*) *Direct Violence.*—This mode of production of a dislocation is rare. The force acts upon the end of one of the bones forming the joint and forces it away from the other bone. A blow or a fall directly upon the head of the humerus will produce such a direct dislocation.

(*c*) *Muscular Action.*—This can only produce a dislocation in certain joints which are predisposed to it by their peculiar construction, such as the shoulder and the temporomaxillary joints and the patella. Throwing a ball or reaching far above the head, especially in a backward direction, is not infrequently followed by dislocation of the shoulder-joint as the result of muscular action. In a similar way yawning or laughing will cause a dislocation of the jaw by muscular contraction, while the head of the bone rests on the articular tubercle. Some individuals have the power of producing a dislocation by voluntary muscular efforts.

Pathology of Dislocations.—The usual results of a dislocation are the rupture of ligaments and of the capsule of the joint. The less frequent effects of a dislocation are fractures of the articular surfaces, a tear, or displacement of the cartilages of the joint, partial or complete rupture of large blood-vessels or nerves, and extensive laceration of the muscles and other soft parts.

Ligaments and Capsule.—The extent to which the ligaments are injured varies according to the rôle which they play in the formation of the joint and the direction of the force. In joints of the ball-and-socket variety, like the shoulder- and hip-joints, the ligaments are not greatly torn, the principal structure injured being the capsule. In hinge joints, like the elbow, wrist, knee, or ankle, the ligaments are apt to be more extensively lacerated or torn from their points of attachment. The ligaments may be either partly or completely torn.

The injury to the capsule may consist of a simple longitudinal or transverse tear, or the entire capsule may be torn from its attachments to the bone and carry a portion of the latter with it. For example, in dislocations of the shoulder, elbow, or hip, the position of the tear in the capsule is always more or less constant. In the shoulder- and the hip-joints it is at the lower portion, in the elbow at the posterior portion, of the capsule.

Injuries of Bone and Cartilage.—Injuries of bones in dislocations may either consist in the tearing off of certain bony prominences or any of the varieties of articular fractures described on p. 80. The articular fracture may simply involve the articular surfaces of the bone, or extend outward from the joint to the shaft, or be in the latter alone, in close proximity to the joint.

An example of a tearing fracture is that of the coronoid process of the ulna in a dislocation of the elbow. Examples of para-articular fractures are those which occur close to the articular surface in dislocation of the head of the humerus (p. 397).

The cartilages may be bruised or chipped, or they may be torn from their attachment, as, for example, a detachment of the semilunar cartilage in dislocation of the knee.

Injuries of Blood-vessels.—This is a comparatively rare complication of a dislocation. In the majority of cases the dislocation has been a forward and inward dislocation of the shoulder, and the vessel involved was the axillary artery or one of its branches. A few cases also have been recorded of injuries of the popliteal vessels in dislocation of the knee, of injury of the anterior and posterior tibial arteries in dislocation of the ankle, and injury of the femoral artery in dislocation of the hip.

The injury of the vessels may involve the artery or the vein or both vessels. The lesion produced in the artery varies. In some cases there was a complete or partial rupture of all the coats of the artery, or of the inner and middle coats alone, with the subsequent formation of a traumatic aneurism. In other cases the wall of the artery did not rupture until a few days after the injury. An injury to the blood-vessels may also occur during efforts at reduction. The lesions produced do not differ from those which occur as a result of recent dislocation. Up to the present time (May, 1907) fifty-six cases of injury to the larger vessels of the axilla as a direct result of a dislocation or in the reduction of a dislocation of the shoulder have been reported. The accident is most to be feared in a reduction of such a dislocation, when the elbow is abducted to the height of the shoulder or is carried across the chest and face in a wide movement

(Stimson[1]). If the dislocation is an old one, the liability to rupture is increased. The symptoms vary according to the extent of the injury to the artery. In the majority of cases a diffuse fluctuating swelling, without bruit or pulsations, appears immediately or within a few hours after the injury. The swelling may reach the size of an adult head, and its rapid appearance is accompanied by syncope, anemia, and signs of shock. The radial pulse is not always absent. If it is present, the injured vessel is probably not the main trunk, but one of its branches. In most of the reported cases the swelling either ruptured spontaneously or was threatening to do so when operation was performed.

In a small number of cases a tumor having many of the characteristics of an aneurism appears in the axilla a few days or weeks after the injury or after the reduction. It increases in size rapidly, and may rupture externally unless operated upon.

The treatment of an injured vessel depends upon whether a swelling has formed rapidly or an aneurism has slowly appeared. In the former class of injuries, *i. e.*, where the rapid appearance shows that the vessel has been completely torn, it is best to operate immediately to prevent gangrene of the limb or pressure upon the nerves. An incision should be made over the injured vessel, which must be found and ligated. Such a method has been resorted to in two cases, both of which were fatal. If an aneurism has formed gradually, conservative treatment is to be recommended, viz., pressure over the artery. If this is not successful, one of the methods of treatment of aneurism referred to in the chapter upon Surgery of Arteries, viz., ligation or suture, should be tried.

The use of the Kocher method is to be especially recommended in the reduction of an old shoulder dislocation (p. 402), but the greater liability to a tear of the artery in breaking up the adhesions around it should be borne in mind.

Schmidt[2] has recently reported a case of a traumatic aneurism of the axillary artery, after a forward dislocation of the head of the humerus. Recovery took place after the ligation of the third part of the subclavian artery.

Injuries of Nerves.—These are even more frequent than injuries of the blood-vessels. Like the latter, injury of the nerves may occur at the time of the accident or later, during efforts at reduction of the dislocation. The nerve may be torn completely across, or it may be only contused, or finally a neuritis may be set up. A complete laceration of a nerve is comparatively rare, the most frequent results of nerve injuries being either a contusion or a neuritis.

The form of dislocation which is most apt to be accompanied by injury of the adjacent nerves is the forward variety in the shoulder-joint. The injury may involve all of the nerves composing the brachial plexus, resulting in general paralysis of the arm or more frequently only the circumflex nerve is involved, with subsequent paralysis and atrophy of the deltoid muscle.

After dislocation of the hip, the sciatic nerve has been involved in the backward variety of dislocation and the anterior crural nerve in the forward variety. Vialle[32] has called attention to the fact that the median nerve is most likely to be injured after a dislocation of the elbow. The ulnar nerve is less often involved, and the radial rarely so. Cases[43] have been reported of laceration of the peroneal nerves as a complication of outward dislocation of the knee.

The diagnosis of a nerve injury as a complication of a dislocation depends upon the extent of the lesion. If the nerve has been completely lacerated, the injury is followed by immediate paralysis of all the muscles supplied by the nerve, and anesthesia over the area of skin to which it is distributed. If the nerve is only contused, there are varying degrees of paralysis, or paresis accompanied by paresthesia or anesthesia, pain, and trophic disturbances. The treatment of such a nerve injury does not differ from that due to other causes than dislocation, and is fully discussed in the chapter upon the Surgery of Nerves.

Repair of Recent Dislocations.—In the majority of cases healing occurs in dislocations in the same manner as in other subcutaneous injuries. The tear in the capsule heals by cicatrization, a thick, unyielding scar showing where the capsule has been torn. The remainder of the capsule, however, remains less tense than before the injury. In a few cases the tear in the capsule remains open permanently, permitting free communication between the joint cavity and some adjacent bursa, like the subscapular in the case of the shoulder. If the articular surface has been injured, especially if its edge has been torn off, the defect is replaced by bone in the majority of cases. A hypertrophy of bone may also occur at the point of insertion of the capsule, resulting in the formation of osteophytes. In elderly people a chronic arthritis, often of the type of arthritis deformans, may follow the dislocation. In cases of fracture of portions of bone to which ligaments or muscles are attached, union of the detached fragment usually occurs. In some cases the fragments may remain as free joint bodies. On the other hand, the fragment may be pulled so far away from its point of attachment that the muscles attached to it lose their function. This factor in the repair of a recent dislocation may play an important rôle in the production of a recurrent dislocation (p. 382). The same is true of muscles or tendons which have been torn from their points of attachments to the bone, so that their close relation to the capsule is disturbed.

Unreduced or Ancient Dislocation.—If a dislocation has not been reduced, it is termed an *unreduced or ancient* one. This subject will be briefly referred to here and more fully discussed under the dislocations of the individual joints.

The general tendency after the occurrence of an unreduced dislocation is toward the formation of a new joint around the end of the displaced bone. A new capsule of connective tissue is formed. The inner aspect of this pseudo-capsule is either smooth or covered with numerous villi. The new capsule is so small and so closely surrounded by cicatricial tissue that the range of motion of the new joint is usually far less than that of the original one. The new joint cavity may communicate with the old one, but may be entirely separated from it. The old capsule may fill up the original articular cavity, or it may become adherent to its edge. In the latter case it may be interposed between the head of the bone and the articular surface and prevent reduction. The formation of a connective-tissue capsule around the end of the displaced bone is accompanied by shrinking of the surrounding muscles, and this latter factor may also be a cause of the irreducibility. The bone upon which the displaced articular end rests assists greatly in the formation of a new articular surface. The latter may consist only of bone, or it may become covered with cartilage. The newly formed articular surface may even be surrounded by an edge of bone which is raised above the level of the remaining surface. Changes also occur in the articular end of the displaced bone, which tend to adapt it to its new location. It becomes flattened at the point of contact with the new joint cavity, but where it no longer touches it, the head becomes irregular and hypertrophy of the bone occurs, resulting in disappearance of the cartilage which originally covered it, or it becomes adherent to the surrounding tissue. The old articular surface or cavity becomes filled up by connective tissue which replaces the cartilage originally lining it. In some cases the cavity is filled by adherent capsule. These changes, which result in the formation of a new joint, combined with the danger of injury to the adjacent blood-vessels and nerves, show the difficulties which are encountered in attempting to reduce an old dislocation by any other method than an operative one. The technic to be employed will be described in connection with the dislocation of the individual joints.

Recurrent or Habitual Dislocations.—In the description of the repair of a recent dislocation (p. 381) attention was called to the fact that under certain conditions a dislocation is likely to recur. Such a recurrence may occur after the slightest exertion, and at such short intervals that the resulting condition is spoken of as a *habitual or recurrent* dislocation. It is most frequently found in the shoulder- or hip-joint, although a number of cases of recurrent dislocation of the patella and the sternal end of the clavicle[5] have been described. The subject has been thoroughly reviewed in two recent articles by Hildebrandt[6] and Perthes.[7] In the majority of cases the capsule is very lax, and many writers have thought that this was the chief cause of the recurrence of the dislocation. In a certain number of cases this laxity undoubtedly plays a rôle. Our knowledge of the true causes in many cases has been greatly increased through operations and by x-ray examinations. Both have shown that in many cases the recurrence of the dislocation is due to other factors. These are the tearing off of the attachment of the supraspinatus and infraspinatus muscles from the greater tuberosity of the humerus, and the breaking off of portions of the rim of the glenoid cavity. Since the systematic use of the x-ray in these cases it has been found that a tearing fracture of the greater tuberosity is a much more frequent accompaniment of dislocations of the shoulder than was formerly thought to be the case. The muscles attached to the greater tuberosity are thus greatly hampered in their normal action of supporting the capsule. The same is true of cases where the subscapularis was torn from its point of attachment. When the tendons of these muscles retract or become attached in an unfavorable place, their function is lost and recurrence of the dislocation is liable to take place.

A fracture which tears off a portion of the inner edge of the glenoid cavity acts in the same manner, and it has been repeatedly observed as a cause of recurrence by Broca, Hartman, and Sick at autopsies, and by R. Volkmann, Hildebrand, and Perthes during operations. A tearing off of the greater tuberosity can be recognized by the use of the x-ray. Views should be taken in several different directions. The best picture of the greater tuberosity is obtained when the arm is rotated outward. A view of the normal shoulder must also be taken for comparison. If a fracture of the greater tuberosity be present, there is an absence of the normal convexity of the upper end of the humerus, the outline being irregular.

A fracture of the rim of the acetabulum (Fig. 173) may play an important part in a recurrent dislocation of the hip. In habitual dislocations of the patella the cause is a lack of tonicity of the extensor muscles of the thigh or elongation of the ligamentum patellæ. The treatment of recurrent dislocations will be considered in the individual joints.

Symptoms and Diagnosis of Dislocations.—A diagnosis can usually be made from certain objective and subjective signs, taken in conjunction with an accurate history of the manner in which the accident occurred. An examination should be made in a systematic manner in every case: (*a*) *Inspection.* The limb should be first inspected to note the position, alterations of contour or of the axis of the limb, or the projection or absence of certain body prominences. The position is often so characteristic that a diagnosis can be made by inspection alone. (*b*) *Palpation.* By this one can learn the relation of the displaced articular ends to each other unless the swelling is too great or the patient is very stout. This method also enables one to ascertain the absence of normal prominences or the presence of abnormal ones. The end of the displaced bone may be felt in an abnormal position. (*c*) *Measurement.* The limb may only appear to be or is actually shortened, and the normal measurements between bony prominences will be altered. The precautions to be taken have been referred to under fractures (p. 89). (*d*) A *skiagraph* should be made in all doubtful cases to confirm the diagnosis of dislocation, and also to ascertain whether there is an accompanying fracture. When the patient is stout, or when considerable swelling exists, the use of the x-ray is especially valuable.

Objective Signs.—*Deformity.*—The attitude of the limb is often so characteristic that simple inspection (Fig. 292) will enable an experienced surgeon to make a diagnosis by this means alone. In stout persons a change in the axis of the limb or a change in position is apt to be overlooked. The relation of the articular surfaces can be determined by palpation unless the swelling is too great. This abnormal position of the articular end of the bone is easily determined in all of the joints except the hip by manipulation. Measurement of the limb will usually show a shortening depending upon the position in which the limb is held.

Loss of Mobility.—The movements of a dislocated joint are usually limited. If any movement of the end of one of the bones is felt, it is always at an abnormal point. The limitation of motion does not disappear even under anesthesia, owing to the fact that it is not due to muscular spasm, but to the tenseness of the ligaments around the joint.

Subjective Symptoms.—*Pain.*—This is usually referred to the dislocated joint, and is increased by movement. The pain is most marked when nerve-trunks are compressed. It may be accompanied by sensory disturbances, such as numbness and tingling.

Loss of Function.—The patient is unable to use the limb. The same symptoms may be present in a fracture or after a severe contusion. It may be entirely absent or very slight.

The *diagnosis from a fracture* cannot be made from the fact that there are abnormal fixation in a dislocation and abnormal mobility in a fracture. In a dislocation the range of movements may be quite free, while in a fracture close to a joint motion is usually limited by muscular spasm. The deformity in a dislocation does not return after reduction, while in a fracture it does. The frequent association of fractures with dislocation necessitates the systematic use of the *x*-ray. A careful *history* should be taken to ascertain how the accident occurred, the position the limb was in, and also whether there is a history of any disease or previous accident.

Treatment.—As a rule, a dislocation should be reduced as soon as the diagnosis has been made. The use of complicated apparatus for extension and counterextension upon the limb has been abandoned since the introduction of anesthesia. Galen was the first to advocate bringing back the head of the bone along the route by which it escaped. His teachings were not followed until the days of Jean Louis Petit in the early part of the eighteenth century. Petit pointed out the necessity of first bringing the head of the bone back to the opening in the capsule before attempting to replace it. One of his successors, Ponteau, improved these methods as applied to dislocations of the hip. The modern methods of reduction by manipulation alone or combined with traction are an evolution of the teachings of Galen, Petit, and Ponteau. The details of the successive steps differ according to the articulation involved and will be described there. The general principles are that the limb is given successive positions, by which the head of the bone is brought opposite the opening in the capsule, which is made to gape widely. The bone is then replaced into its cavity. The chief obstacles to reduction are the ligaments and the capsule. The muscles around the joint, which are usually spasmodically contracted, also play an important part in rendering reduction difficult.

At times this muscular spasm can be overcome and the dislocation reduced without the aid of an anesthetic, but it is usually better to administer one, preferably ether. In some cases a ridge of bone or the edge of the articular cavity into which the displaced bone fits, prevents easy reduction of the dislocation. Examples of these are dislocations of the elbow and hip. The successive positions to be given to the limb depend upon a study of the anatomic peculiarities of the individual joint and the behavior of its ligaments. In some cases the displaced articular surface can be brought close to the opening by rotation of the shaft, as in the case of a shoulder dislocation. In other joints it is necessary to flex the limb, as in the case of the hip, in order to accomplish the same result. In some the dislocation is exaggerated in order to use the shaft as a lever to release it from some projecting ridge of bone, as in the elbow. When reduction has been accomplished, the bone often goes back with a snap. The contour of the limb is restored, and the movements of the joint are free again.

If it is impossible to reduce a recent dislocation, the following obstacles must be thought of: (*a*) Interposed portions of the capsule; (*b*) interposed muscles or tendons or sesamoid bones; (*c*) torn-off fragments of bone; (*d*) a fracture of the shaft close to its articular end, which would prevent its being used as a lever for reduction. The latter condition is seen most frequently in the shoulder (Fig. 290). At times the capsule is pushed into the joint in front of the displaced articular end, and the dislocation recurs within a short time (p. 382). If a recent dislocation is irreducible, two methods of treatment are to be considered. The first consists in permitting the formation of a new joint and is to be preferred in old and feeble individuals. The second and far more preferable method is to perform an arthrotomy toward the end of the second week after the accident, and then reduce the dislocation. The obstacle to reduction is searched for and removed, and the case then treated as if it were a simple reducible dislocation.

The treatment of a compound dislocation requires the strictest asepsis as an essential factor in the treatment. In doubtful cases it is advisable to irrigate the joint thoroughly before reduction is attempted. In certain joints whose articular surfaces are flat, it is at times impossible to prevent recurrence of the dislocation unless the two bones are sutured. Such an operative procedure will often give the best results in dislocations at the acromioclavicular joint, and will be described in connection with the latter.

The after-treatment of a dislocation is usually quite simple. A bandage or splint should be applied, which will keep the joint immobilized for a period of two weeks, after which passive motion and massage can be begun for fifteen minutes twice daily, the splint or bandage then being reapplied for another two weeks.

Active motion should not be permitted until the end of the third to the fourth week, and the range of movement should be limited so that the tear in the capsule is not reopened. In some joints, like the acromioclavicular, a special form of retention apparatus is needed. The use of gymnastic apparatus after the fourth week is to be recommended in dislocations of the shoulder, elbow, and ankle. The treatment of dislocations complicated by fracture will be considered under each joint.

The accidents which are liable to occur during the reduction of a dislocation are: (*a*) Bruising or laceration of the skin; (*b*) injuries of the blood-vessels or nerves; (*c*) fractures of the shaft near the displaced articular end. To prevent the first-named accident it is best to wrap a towel or some gauze around that part of the limb which is grasped while the manipulations or traction are being made. Injury of the blood-vessels and nerves has been discussed on p. 379. Fractures of the dislocated bone during reduction have occurred in dislocations of the shoulder, hip, and knee. They have been known to take place in the reduction of both recent and old dislocations. Such accidents have become a rarity since the introduction of anesthesia and the use of modern methods of manipulation.

Spontaneous Dislocations.—The name spontaneous dislocations has been given to those displacements of the articular ends which occur as the result of disease, either after a slight trauma or without the history of any injury. Although the term spontaneous does not fit all the cases, it has continued to be employed to designate this variety of dislocation. The names proposed by other writers have been pathologic, symptomatic, gradual, inflammatory, and secondary dislocations. Its occurrence has been known since the earliest times. Petit, quoted by Graff,[8] suggested in 1732 that the dislocation was the result of an articular hydrops. Later investigations have shown that the cause varies greatly, the cases being best divided, after the suggestion of von Volkmann, into four groups, as follows:

1. Dislocations by distention.
2. Dislocations by destruction.
3. Dislocations by deformity.
4. Paralytic dislocations.

1. *Dislocations by Distention.*—These have been known to occur after the following acute infectious diseases: Typhoid, scarlatina, measles, diphtheria, pneumonia, variola, influenza, gonorrhea, and as a complication of pyemia. There is some difference of opinion as to the manner in which the displacement occurs. It has been the generally accepted opinion that a simple serous effusion would not suffice to explain the dislocation. In the majority of cases the exudate is of a more inflammatory character, either seropurulent or purulent, and causes a distention of the capsule and surrounding ligaments, so that the head of the bone is forced from its articular cavity either through the pressure of the fluid combined with the laxity of the capsule or the capsule itself is destroyed so that dislocation occurs quite readily. Some writers (Stimson[9]) believe that the displacement is the result of violent muscular contraction. Graff is of the opinion that the exudate itself is rarely the cause of the spontaneous dislocation, but that its occurrence is favored by defects in the rim of the glenoid cavity or acetabulum, as the result of the inflammatory process either through the destructive action of the organisms concerned or as the result of pressure of the head. The latter factor is to be especially considered in the spontaneous dislocations of the hip.

2. *Dislocation by Destruction.*—That displacement of the articular ends frequently occurs as a complication of a tuberculous arthritis is well known. Cases of acute osteomyelitis of the ends of the long bones, especially of the upper end of the femur, have been reported by Bruns,

Hansell, Ducroquet, and Besancon,[10] in which dislocation of the adjacent joint resulted.

In both tuberculosis and acute osteomyelitis the dislocation is due primarily to a destruction of the head of the bone, with secondary displacement as the result of a number of different factors, *e. g.*, muscular action, position of the limb, or cicatricial contraction. The degree of dislocation, complete or incomplete, varies according to the amount of destruction of the bone. Such dislocations have also been observed as the result of bone metastases of malignant growths (Fig. 285), such as sarcomata or carcinomata. Of the carcinomata, the primary tumor is usually in the breast, thyroid, or prostate.

3. *Dislocations by Deformity.*—In this class are included those disloca-

FIG. 284.—UPWARD AND BACKWARD DISLOCATION OF HIP FOLLOWING TYPHOID FEVER. Kindly lent by Dr. C. M. Jacobs.

tions which occur as the result of an arthritis deformans or in the course of tabes dorsalis or of syringomyelia. The dislocation is usually an incomplete one or subluxation. In the case of arthritis deformans it is most frequent in the wrist or fingers in the upper, and in the hip, knee, or toes in the lower, extremity. In tabes dorsalis the subluxation is usually found in the hip or knee, while in syringomyelia it occurs in the shoulder or elbow. Madelung[11] has described a form of spontaneous dislocation of the wrist or elbow which occurs gradually, without much trauma, during adolescence. It may require three to four years to develop, but cases have been reported in which it was fully developed within five to six months. Abadie[12] has collected all the published cases and divides them into four varieties:

(*a*) Bilateral hyperostosis of the elbow, often congenital, with simple bony thickening of the wrist-joint or progressive and often overlooked dislocation of the same joint. (*b*) Simple subluxation of the radius in the wrist- and elbow-joints, bilateral, easily replaced, often painless, and without changes in the bones. (*c*) Dislocation which is difficult or impossible to replace, with faulty position of elbow. (*d*) The same as the last, with bending of the radius. The last two are usually unilateral.

4. *Paralytic Dislocation.*—These occur only in severe cases of anterior poliomyelitis. The joints most frequently affected are the shoulder and hip, and the dislocation occurs either spontaneously or in consequence of bearing weight upon or using the limb. Dislocation may also occur when one set of muscles are paralyzed and traction upon one of the bones is exerted by the opposing muscles. Examples of the latter are seen after

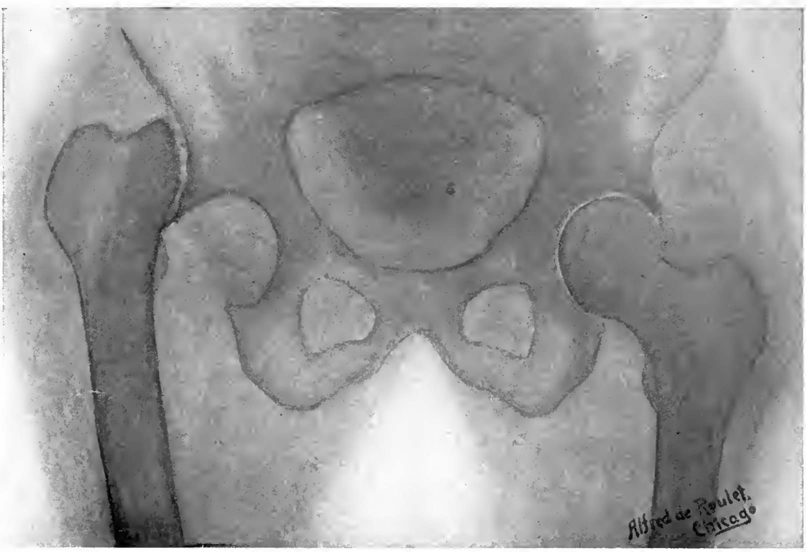

FIG. 285.—UPWARD DISLOCATION OF NECK AND SHAFT OF FEMUR, FOLLOWING ABSORPTION OF HEAD, THE RESULT OF A METASTATIC SARCOMA, PRIMARY GROWTH IN TESTIS (X-RAY COPY).

paralysis of the muscles of the thigh, followed by subluxation of the knee backward.

Diagnosis of Spontaneous Dislocations.—The diagnosis can usually be made by a consideration of the history, combined with the examination of the joint and of a skiagraph. The actual dislocation is often preceded by pain and swelling of the joint. In the case of dislocations by distention the history will reveal the etiologic factor to be one of the infectious diseases enumerated on p. 386. Examination will reveal all the signs of a dislocation, and this can be eadily confirmed by a skiagraph (Fig. 285). In dislocation by destruction the same methods of examination will show the existence of a healed or recent tuberculous or ordinary suppurative osteomyelitis. In the absence of these a search should be made for a primary sarcoma or carcinoma. The diagnosis of a dislocation due to a neuropathic cause, such as tabes, syringomyelia, or infantile paralysis, presents no difficulties and depends upon the recognition of the primary disease. In syringomyelia the dislocation may be of the habitual or recurrent type. In a paralytic dislocation a "flail joint" is usually present, permitting a wide range of motion of the articular ends.

Treatment.—This varies according to the cause. In the distention dislocations there are two methods:

(*a*) A bloodless reduction of the dislocation and (*b*) reduction by operative means. An effort should be made in every case to reduce the dislocation by the same methods of manipulation, aided by traction, as are employed in the reduction of traumatic dislocations of the corresponding joints. In the majority of cases ordinary manual traction does not suffice on account of the adhesions which have formed around the head of the bone. It is advisable, in many cases, to employ some mechanic appliance, like the Bartlett machine, or to use a Buck's extension for some weeks before efforts at reduction are begun. The treatment of other forms of spontaneous dislocations is considered in the chapter upon Diseases of the Joints.

Congenital Dislocations.—A congenital dislocation is one in which a displacement of the articular ends of the joint has occurred during intra-uterine life. It is probable (Whitman[13]) that in some cases the dislocation is a subluxation only at birth, but becomes complete through muscular action and the use of the limb in standing or walking. Congenital dislocation occurs most frequently in the hip. A few cases have been reported of this condition in the knee, patella, ankle, shoulder, elbow, and wrist. For practical purposes one need only consider those of the hip, which are fully treated in Chapter XXVIII, p. 528.

DISLOCATIONS OF THE LOWER JAW.

When the mouth is opened, the articular eminence (Fig. 286) limits the degree of motion of the condyle of the lower jaw. If, however, the mouth is widely opened, as in yawning, laughing, or vomiting, the condyle may slide past the articular eminence and cannot return. Owing to the fact that the articular eminence is not developed until the age of puberty, dislocations of the lower jaw are very rare in early life. In the majority of cases the dislocation is bilateral and forward. The other varieties of dislocation are very rare. They are: (*a*) Dislocation backward, which is always accompanied by fracture of the anterior wall of the bony auditory canal. Steiner, in 1893, collected 14 cases of this injury. (*b*) Dislocation upward. Only one case has been reported of this form. The condyle was forced upward through the articular surface into the cranial cavity. (*c*) Dislocation outward. Only four cases have been reported.

Dislocation of the Jaw Forward.—This occurs most frequently in middle-aged persons. They are more frequent in women than in men, owing to the fact that in women the condyle is smaller and has a wider range of mobility than in men. The dislocation may be unilateral, but is most often bilateral. There is usually no tear in the capsule, the latter being simply stretched.

Fig. 286.—Forward Dislocation of Jaw.
1, Condyle resting upon, in, or in front of articular eminence; 2, note forward displacement of teeth of lower jaw.

The manner in which the dislocation is produced is as follows: When the mouth is widely opened, the external lateral ligament of the temporo-maxillary joint is relaxed and the condyle moves forward. When the mouth is partly closed, the ligament becomes tense and prevents the return of the condyle. If, now, any of the muscles of mastication, especially the external pterygoid muscles, contract suddenly, the condyle is pulled forward. A dislocation may also follow the ingestion of too large a morsel of food or a blow or a fall upon the chin.

Symptoms.—In bilateral dislocation the mouth is held widely open. The chin and lower jaw project in front of the upper (Fig. 286). The lower jaw is fixed, so that the mouth cannot be closed. There is a depression in front of the ear corresponding to the location of the empty glenoid cavity. The condyle can be felt just below the zygoma. The masseter and temporal muscles are tense, and the patient is unable to chew his food. Severe pain may be present, due to pressure upon the branches of the trifacial nerve.

In a unilateral dislocation the depression over the glenoid cavity and the prominence under the zygoma due to the displaced

Fig. 287.—Method of Reduction of Dislocation of the Jaw.

Both thumbs having been covered with several turns of a roller bandage, are inserted into the mouth over the molar teeth, the fingers of both hands being placed on the outer side of the jaw. Pressure is made in a downward direction by both thumbs, as described in the text.

head are present only on one side. This chin is deviated toward the normal side.

Treatment.—If seen early, there is no difficulty in reduction. The method usually employed is to cover the thumbs with some soft material, such as bandage muslin, and then to insert them over the molar teeth upon either side of the lower jaw. The remaining fingers grasp the lower border of the jaw from the outside (Fig. 287). While the thumbs exert pressure in a backward and slightly downward direction, the chin is lifted up by the remaining fingers. As soon as one can feel that the condyles have passed across the articular eminences, the thumbs are quickly withdrawn and the jaws permitted to come together. In unreduced dislocations of long standing attempts should be made to break up the adhesions by moving the jaw up and down before any attempt at reduction is made.

The jaw should be immobilized with a four-tailed or Barton bandage for two weeks, during which only liquid food is given. Even after the bandage has been removed the patient should be warned not to open the mouth too widely, since recurrence of the dislocation is not uncommon.

In irreducible cases an arthrotomy is indicated, the adhesions being broken up. If it is impossible to effect a reduction after arthrotomy, very good results can be obtained by resection of the condyle.

DISLOCATIONS OF THE CLAVICLE.

Dislocations of the clavicle are comparatively rare. They occur most frequently between the ages of thirty and fifty. Dislocations of the acromial end are more common than those of the sternal end. Simultaneous dislocation[14] of both ends of the clavicle is rare (p. 395).

Dislocations of the Sternal End of the Clavicle.—There are three varieties of dislocation of this end of the clavicle: (*a*) Forward; (*b*) upward; and (*c*) backward.

(*a*) **Forward Dislocation.**—This occurs more often than either of the other varieties. It results from force applied in a backward direction at the shoulder, such as a fall upon the shoulder or upon the outstretched hand. It may occur as a recurrent or habitual condition after breaking up adhesions in the shoulder-joint.[15]

Symptoms.—The sternal end of the clavicle projects under the skin at the upper portion of the sternum, a little below and inward from its normal position. If the dislocation is bilateral, as rarely[16] occurs, there are two projections over the upper end of the sternum. In some cases the empty joint cavity can be felt. The prominence due to the displaced head moves with the movements of the shoulders.

Treatment.—Reduction is effected by placing the knee against the spine, between the scapulæ, and drawing the shoulders backward while pressure is made over the displaced articular end.

Although reduction is easy, the displacement tends to recur and a habitual or recurrent dislocation results. To prevent this, a soft pad is placed over the end of the bone. The pad is held by a figure-of-eight bandage. Instead of this method one can keep the end of the clavicle reduced by strips of adhesive plaster, applied while the shoulders are pulled backward.

Various operative methods have been suggested. Of these, wiring and arthrodesis require special mention. Wiring of the sternal end of the clavicle to the sternum itself has been warmly recommended by Fritz Koenig. Katzenstein[17] prefers to perform an excision of the articular surfaces called arthrodesis. Only six cases of the latter have been reported. Operative methods are to be especially recommended for recurrent cases.

(*b*) **Upward Dislocation.**—This is due to a sudden depression of the shoulder and acromial end of the clavicle, causing the bone to escape through a tear in the upper part of the capsule.

Symptoms.—The shoulder is lower than the opposite one. The head of the bone is felt in front of the trachea. If the displaced bone compresses the trachea and esophagus, dyspnea and dysphagia may be the most prominent symptoms.

Treatment.—By drawing the shoulder outward and making direct pressure over the displaced sternal end, reduction is easily effected. It is best maintained by keeping a pad or some adhesive strips over it and applying a Velpeau bandage.

(*c*) **Backward Dislocation.**—This has seldom been observed, and may be due to direct violence, such as a blow over the inner end of the clavicle or pressure in a forward direction upon the back of the shoulders. As in the other varieties, the dislocation may be complete or incomplete.

Symptoms.—The symptoms are quite characteristic. There is a depression instead of a prominence at the inner end of the clavicle.

The acromial end of the clavicle is quite prominent, while the sternal end lies behind the upper part of the sternum. The shoulders are thrown forward, while the movements of the head and neck are painful. Serious symptoms as the result of pressure upon the adjacent nerves, blood-vessels, trachea, and esophagus are rare. Pressure upon the trachea and larger vessels causes dyspnea, cyanosis, and an absence of the radial pulse upon the compressed side.

Treatment.—Reduction is readily effected by pulling the shoulders backward and outward. If the dislocation cannot be reduced or if symptoms of compression exist, arthrotomy should be performed early. Recurrence of the displacement can be avoided by dressings which hold the shoulder down and back.

Dislocations at the Acromial End of the Clavicle.—There are three varieties of dislocation at the outer end of the clavicle: (1) Upward or supra-acromial; (2) subacromial or downward and backward; and (3) subcoracoid or downward and forward under the coracoid process.

1. **Supra-acromial Dislocation.**—This is the most frequent variety of dislocation at the outer end of the clavicle. It may be incomplete or complete. Both are the result of a blow or fall upon the shoulder, the force acting in a vertical direction upon the acromion process and separating it from the clavicle. No doubt the sudden contraction of the trapezius plays a part in pulling the outer end of the clavicle upward. If the liga-

ments which bind the clavicle to the coracoid process, viz., the trapezoid and conoid ligaments, are torn, a complete dislocation results. If only the ligaments which surround the capsule of the acromioclavicular joint are torn, the dislocation is usually an incomplete one.

Diagnosis.—In an incomplete dislocation, in addition to the localized pain and swelling, there is deformity. The clavicle is slightly elevated above the level of the acromion. This prominence can be distinctly recognized by palpation of the outer end of the clavicle.

In the complete dislocation the above symptoms are all more marked. The diagnosis can be readily made from the deformity. Instead of the normal convexity of the shoulder, one observes a step-like break in the contour (Fig. 288). The clavicle can be felt $\frac{1}{2}$ to 1 inch above the level of the acromion. The prominence due to the displaced outer end of the clavicle can be moved in all directions.

When the dislocation is reduced by pressure upon the bony prominence, it tends to recur as soon as the pressure is relieved. The only conditions

Fig. 288.—Dislocation Upward of the Acromial End of the Clavicle.
The arrow points to the depression lying between the bony prominence, caused by the separation of the acromial end of the clavicle from the acromion process of the scapula.

which need to be differentiated are a fracture of the outer end of the clavicle and a fracture of the acromion process.

In a fracture of the outer end of the clavicle the point of abnormal mobility lies closer to the sternal end of the clavicle, as can be determined by measurement of both clavicles. The deformity is less easily corrected, and there is more pain. Crepitus cannot always be elicited, but when found, it will confirm the diagnosis of fracture.

In a fracture of the acromion process the arm is usually lower than upon the uninjured side, and a deformity, if visible, is at a lower level than in a supra-acromial dislocation of the clavicle (Fig. 288). The deformity can be readily corrected by lifting the arm. The presence of crepitus will aid in distinguishing the two conditions.

Treatment.—Reduction of the displaced outer end of the clavicle is quite easy, but the deformity readily recurs. Reduction can be effected by lifting the arm so as to lift the shoulder upward or upward and backward, and at the same time pressing the clavicle downward. One of the simplest methods of fixation is to place a small pad of gauze over the joint and then apply a strip of adhesive plaster across the shoulder in a manner similar to that of the second step of the Sayre dressing (Fig. 98). The strip of plaster is carried around the elbow, and its ends brought over the dislocated joint by crossing them. The arm can be further supported by a Velpeau bandage.

In some cases, especially if the dislocation is an incomplete one, the clavicle can be perfectly held by some form of retentive apparatus. At times it is impossible to reduce the dislocation completely or to hold it reduced. It seems probable, from the observation and experience of Kreeke, Poirier, Rieffel, and Sheldon[18]—(1) that the acromioclavicular ligaments are torn in all cases; (2) that the conoid ligament is sometimes torn in incomplete dislocations; (3) that the conoid ligament is always torn in complete cases; (4) that both the conoid and trapezoid ligaments are usually torn in the complete cases. These investigations and the difficulty of maintaining reduction in cases of complete dislocations have led many surgeons to employ operative methods. If the displacement is extreme, indicating that the coracoclavicular ligaments are torn, suture of the clavicle to the acromion is indicated. The best suture materials are kangaroo tendon, silk, or Pagenstecher linen thread. The suture should be passed through the clavicle and the coraco-acromial ligament[19] or, if the tear is extensive, the suture should be passed through the acromion process. Wire sutures are objectionable because they irritate the skin and often require to be removed.

2. **Subacromial Dislocation.**—This is very rare, scarcely a dozen cases having been reported.

It is the result usually of a direct force exerted in a downward direction upon the outer end of the clavicle while the arm is abducted. The outer end of the clavicle lies beneath the acromion process.

Diagnosis.—The contour of the shoulder is changed, owing to the fact that the outer end of the clavicle is absent. Palpation of the shaft of the clavicle shows that it is inclined downward and that the outer end of the clavicle cannot be felt in its normal position, but lies beneath the acromion. The movements of the arm are greatly interfered with, especially adduction and abduction. Paresthesia may be present as the result of pressure upon the nerves of the brachial plexus.

Treatment.—Reduction is made by flexing the elbow and pulling the shoulder outward, the arm being held parallel to the chest and the clavicle pushed upward. After reduction a pad is placed in the axilla and a Velpeau bandage applied.

3. **Subcoracoid Dislocation.**—Only a few cases of this form have been reported. The diagnosis can be made from the absence of the outer end of the clavicle in its normal position. The clavicle is inclined downward and outward and its acromial end is found lodged in the axilla.

4. **Supraspinous Dislocation.**—A pure backward form of dislocation of the clavicle has been described by some writers and called a supraspinous dislocation. Cases of this kind have been described by Davis, Grossman,[20] and Klar.[21] The injury followed a direct violence. In two a heavy kettle fell upon the shoulder, and in the third the shoulder was

crushed between two heavy stones. The outer end of the clavicle was displaced directly backward and could be felt just below the spine of the scapula. Reduction was easily effected when the patient was placed upon his back by grasping the clavicle and pulling it up and forward.

Simultaneous Dislocation of Both Ends of the Clavicle (Total Dislocation).—In 1889 Lucas was able to collect only eight cases of this injury. Since this time two more cases have been reported by Gibb[22] and Cousins.[23] In the majority of cases the cause was direct violence, such as a compression of both shoulders between two cars moving in opposite directions, so that the clavicle of one shoulder was forced from its attachments at both ends.

The diagnosis can be readily made by inspection and palpation: the sternal end has always been displaced forward. The reduction is easy, but the displacement tends to recur easily.

In a recent case[23] Cousins employed sand-bags over both ends of the clavicle, the patient being kept in bed. The result was excellent.

DISLOCATION OF THE SHOULDER.

Frequency and Classification.—Dislocations of the shoulder constitute over 50 per cent. of all the dislocations of the body. They are rare in childhood and early life, but increase in frequency toward middle life, at which age they are the most frequent. The largest proportion of cases occur between the ages of fifty-five and seventy.

The injury is more frequent in men than in women during the middle period of life, in the proportion of four to one. This is due to the fact that men are more often engaged in industrial pursuits during these years than women. In later life the injury occurs with equal frequency in both sexes.

The classification of dislocations of the shoulder which is recommended by French and German surgeons differs from that employed by English and American surgeons.

The classification as recommended by the French and German writers is as follows:

A. Dislocations forward (preglenoidal).
   1. Axillary or subglenoid, with its extreme form, the erect.
   2. Subcoracoid.
   3. Subclavicular or intracoracoid.

B. Dislocation backward (retroglenoidal).
   1. Subacromial.
   2. Infraspinous or subspinous.

The classification of the majority of English and American writers differs slightly from the above in creating a new class of downward dislocations, which includes the subglenoid and erect varieties. It is as follows:

A. Anterior or forward dislocations.
   1. Subcoracoid.
   2. Subclavicular or intracoracoid.

B. Downward dislocations.
   Subglenoid with subvariety, the erect.

C. Posterior or backward dislocations.
   1. Subacromial.
   2. Subspinous.

D. Upward dislocations.
   Supraglenoid.

The latter classification seems to be the most satisfactory and will be adopted here.

Dislocations of the shoulder may be the result of direct or indirect violence or of muscular action. In the majority of cases the injury is due to indirect violence, usually a fall upon the outstretched hand or upon

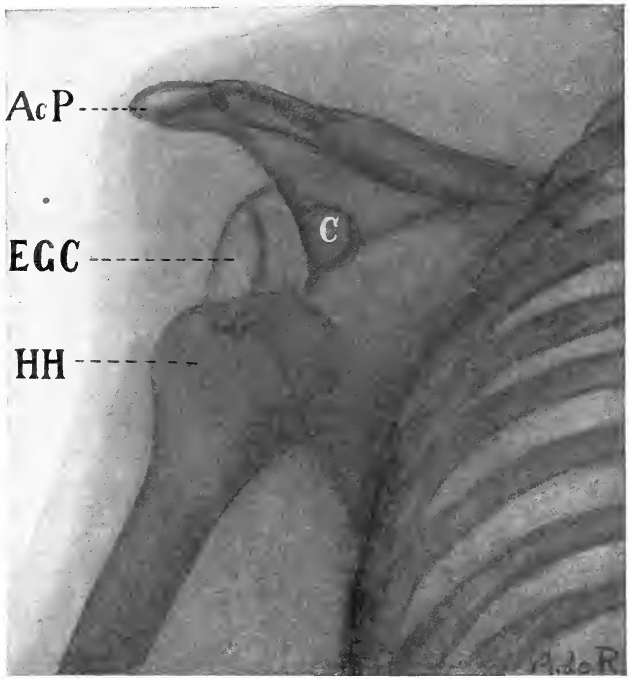

FIG. 289.—X-RAY OF SUBCORACOID DISLOCATION OF THE SHOULDER-JOINT.

C, Coracoid process, below which lies the head of the humerus (HH); EGC, empty glenoid cavity; AcP, acromion process of scapula. Note the flattening of the shoulder below the acromion process due to the absence of the head of the humerus.

the elbow. The arm is hyperabducted, and the head is brought into contact with the weakest part of the capsule, viz., its lower and inner part. The greater tuberosity comes into contact with the upper edge of the glenoid cavity, which latter structure serves as a fulcrum so that if abduction continues, the head of the bone leaves the capsule at its lower and inner portion. As the result of the contraction of the deltoid, pectoralis major, and latissimus dorsi muscles the head is drawn across the anterior lip of the glenoid cavity. When the elbow is again brought to the side, the head rises so as to lie beneath the coracoid process in the subcoracoid variety, or beneath the clavicle in the subclavicular form.

If the head does not travel forward, it may rest beneath the lower edge of the glenoid cavity, constituting either the subglenoid or the erect variety. If the head moves upward and backward (instead of upward and forward), the dislocation becomes a subspinous or subacromial one.

In dislocations which are due to direct violence the cause is a blow or a fall upon the shoulder, especially over the greater tuberosity of the humerus, forcing the latter downward.

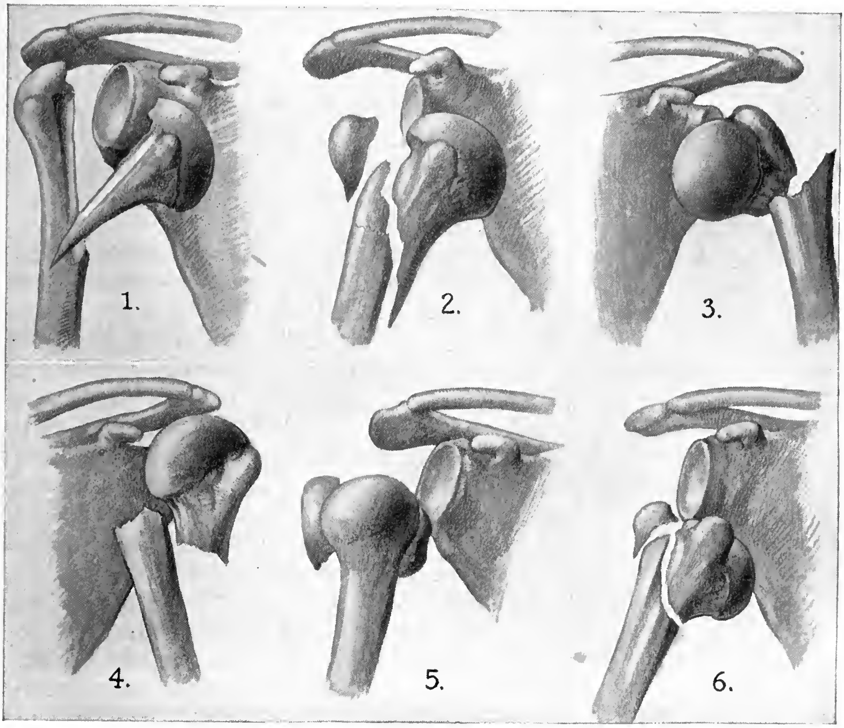

Fig. 290.—Various Forms of Fractures of the Upper End of the Humerus Associated with Dislocation of the Head of Humerus (after Robert Jones).

1, Split fracture of shaft of humerus with subcoracoid dislocation of head; 2, oblique fracture of upper end of humerus with subcoracoid dislocation and separation of greater tuberosity; 3, fracture of surgical neck of humerus, with dislocation of head; 4, fracture of surgical neck of humerus, with displacement upward of head and inward of shaft; 5, subglenoid dislocation of humerus, with separation of greater tuberosity to outer side, and lesser to inner side; 6, subglenoid dislocation of humerus, with fracture of anatomic neck and separation of greater tuberosity. This illustration was made from skiagraphs.

Dislocations may also be due to muscular action. In this variety the deltoid pulls the humerus upward. At the same time the pectoralis major and latissimus dorsi try to pull it downward. The result is that the head of the bone is forced from its socket by the leverage of these muscles. Such dislocations have been reported as occurring after violent muscular efforts, such as throwing a ball or during epileptic convulsions.

Pathology of Recent Dislocations.—The capsule is extensively torn at its inner and lower portions, between the tendons of the subscapularis and the long head of the triceps. If the capsule is very much relaxed, a dislocation may occur without any tear in the capsule. Three cases[9] of the latter conditions have been reported.

The muscles and tendons which strengthen the capsule and are in intimate relation with it, like the subscapularis, teres minor, supraspinatus, and infraspinatus, are often extensively contused and lacerated. If the points of attachments of these muscles are torn, the lesion may play an important part in the production of recurrent or habitual dislocation (p. 382).

The tendon of the long head of the biceps is seldom torn. It may, however, become displaced from its groove between the greater and lesser tuberosities. This is especially apt to be the case if the greater tuberosity be torn off. The tendon may then become wedged between the head and the glenoid cavity, or be wound around the surgical neck of the humerus and be an obstacle to reduction. The subscapularis muscle is at times penetrated by the dislocated head.

The systematic use of the x-ray by many surgeons in all cases of suspected bone and joint injury, and the greater frequency of operations for the reduction of a dislocated shoulder, have shown that this injury is not infrequently complicated by fractures of the glenoid cavity or of the upper end of the humerus. The occurrence of these complications were known and described by many of the older surgeons. In 1886 McBirney collected 117 cases. In a recent article by Robert Jones[24] the entire subject is reviewed. Out of 200 consecutive cases of complicated dislocations of the shoulder which were radiographed, Jones found 22 fractures at the upper end of the humerus. Sixteen were of the surgical neck. In the order of frequence he would tabulate (Fig. 290) fractures of the shoulder connected with dislocation as follows: (*a*) Fractures through the surgical neck. (*b*) Separation of the greater tuberosity. (*c*) Fracture through the anatomic neck, embracing the tuberosities. (*d*) Fracture through the neck of the scapula, embracing the coracoid. (*e*) Separation of the lesser tuberosity. (*f*) Fracture of the rim of the glenoid cavity. (*g*) Separation of the anatomic neck, not including the tuberosities. The head of the bone may take any position. It may be rotated and even at times so completely reversed that the fractured end of the upper fragment is in apposition with the glenoid cavity.

The injuries of vessels and nerves in connection with dislocations of the shoulder have already been described (p. 379). These injuries are especially likely to occur when the head has penetrated the subscapularis muscle. With the exception of a rupture of the subscapular vessels, lacerations of the larger branches of the axillary artery are comparatively rare.

Temporary cyanosis and edema and transitory pareses are quite common, especially a paralysis or paresis of the circumflex nerve with resultant atrophy of the deltoid muscle.

The pathology of ancient, *i. e.*, unreduced, as well as that of recurrent, *i. e.*, habitual, dislocations has been described on pp. 381 and 382.

In the unreduced dislocations of the shoulder the head forms a new articular surface, by friction, at the edge of the glenoid cavity. A new capsule is formed from the connective tissue around the displaced head. The new capsule, as a rule, is firmer and permits less movement than the old one. The glenoid cavity becomes obliterated, and the head of the bone flattened to adapt itself to the new articular surface. In a recurrent dislocation the changes are essentially those described on p. 382.

Diagnosis.—The symptoms of all the forms of dislocations of the shoulder are quite similar. The chief difference is that the head of the bone is either to be felt or seen at different places. The patient inclines his head and body toward the injured side. The subjective symptoms are pain in the shoulder, often referred along the arm, as the result of pressure upon the nerves of the brachial plexus.

FIG. 291.—ANTERIOR VIEW OF DISLOCATION OF SHOULDER-JOINT.

Same case as shown in Fig. 292. N, Normal shoulder. Note the absence of prominence of the acromion process, and the presence of the normal convexity of the shoulder. D, Dislocated shoulder. Note the prominence of the acromion process and the flattening of the shoulder, due to absence of the head of the humerus.

(a) Subcoracoid Dislocation.—Inspection of the shoulder of the injured and uninjured sides shows that the normal convexity of the shoulder is absent upon the injured side (Fig. 291). The shoulder is distinctly flattened, and there may even be a depression below the acromion. This flattening is best seen by standing either directly in front of or behind the patient (Fig. 291). The convexity of the normal shoulder is due to three factors: (*a*) the acromion process; (*b*) the deltoid muscle; and (*c*) the head of the humerus. When the latter has left the glenoid cavity, the most important of these three factors is absent, so that the shoulder loses its normal convexity. Inspection also shows that the axis of the humerus is changed. Instead of being parallel to that of the opposite humerus, an imaginary line drawn through the dislocated humerus meets that of the opposite one a little beyond the patient's head (Fig. 291).

The elbow is abducted. By *palpation* one can feel a depression or lack of resistance below the acromion process, so that the fingers can be deeply pressed in. If an attempt be made to grasp the head of the humerus, as is shown in Fig. 105, it will be found to be absent in its normal position. Further examination will show that the head can be felt just below the coracoid process. The head can also be grasped by inserting the fingers high up into the axilla. The arm is almost completely fixed.

Voluntary rotation and abduction are often present to a slight extent, but it is impossible to carry out passive movements unless the capsule is greatly torn. If such be the case, it is often possible to move the arm passively to some extent in all directions.

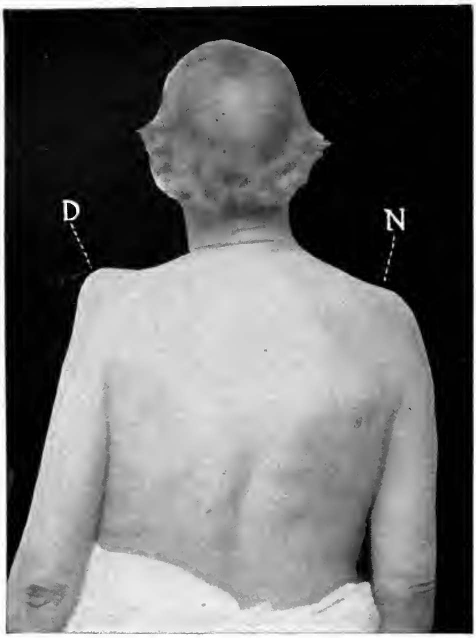

Fig. 292.—Posterior View of Subcoracoid Dislocation of Shoulder-joint.
Same case as shown in Fig. 291. N, Normal shoulder; D, dislocated shoulder.

In very stout patients palpation of the shoulder region is very difficult, and a dislocation may be easily overlooked. In such cases it is advisable to have a skiagraph made as soon as possible after the accident. If this cannot be secured, it is best to administer an anesthetic and continue the examination.

The abducted elbow usually resists all efforts to bring it nearer to the side of the body. The hand cannot be brought to the opposite shoulder (Dugas' test). If the capsule be extensively torn, this sign may be absent.

(b) Intracoracoid or Subclavicular Dislocations.—This variety is very uncommon. Its signs are the same as in a subcoracoid dislocation, except that the arm is not so much abducted and the head can be felt where the pectoralis major and deltoid meet, *i. e.*, just below the outer end of the clavicle. The shoulder is markedly flattened. Bardenheuer has reported two cases in which the dislocated arm was fixed in complete horizontal abduction.

(c) Subglenoid Dislocations.—The signs of this form resemble greatly those of the subcoracoid variety. The chief difference is that the head can be readily palpated in the axilla. The depression below the acromion is very deep, and the flattening of the shoulder is quite marked. The axis of the shaft of the humerus, when prolonged, passes below and to the inner side of the glenoid cavity. The abduction of the elbow is also more noticeable than in a subcoracoid dislocation. When the arm is measured from the acromion process to the external condyle (Fig. 106), it is longer than that of the opposite side. In an erect dislocation (luxatio erecta), which is a variety of subglenoid dislocation, the elbow is abducted to such an extent as to lie at the level of the head. Only a few cases of this form have been observed.

(d) Subspinous and Subacromial Dislocations.—Von Geyer (quoted by Hoffa) was able to collect only thirty cases of this form of dislocation. In the subacromial variety the head penetrates the posterior wall of the capsule and is found beneath the acromion process. In the subspinous variety the head lies further back beneath the spine of the scapula (Fig. 290). The shoulder, when viewed from the front, seems broader than that of the opposite side. The axis of the arm is directed backward, the elbow being displaced considerably forward, especially in the subspinous variety. The coracoid process and end of the acromion are very prominent. The arm is adducted and quite fixed. The glenoid cavity can be felt to be absent, and, by rotating the arm (Fig. 105) while the shoulder is palpated, the head of the humerus can be felt behind and below the acromion or the spine of the scapula.

Fig. 293.—First Step in Reduction of a Dislocation (Subcoracoid) of Shoulder-joint by the Kocher Method.

The elbow is pressed closely to the side of the chest.

Diagnosis of Complications of Shoulder Dislocations.—*Fractures.*—The *x*-ray has been of the greatest aid in the diagnosis of this form of complication. In the majority of cases of fracture of the surgical or anatomic neck associated with dislocation of the head the diagnosis can be made without a skiagraph by the fact that in addition to the flattening of the shoulder and palpation of the head in an abnormal position, which are characteristic of a dislocation, the head of the humerus does not rotate with the shaft. In a dislocation accompanied by fracture the ecchymosis is much greater than in a simple dislocation. Fractures of the tuberosities can hardly be recognized except by the use of the *x*-ray. The operative treatment of this complication is mentioned on p. 176. The same is true of fractures of the glenoid cavity unless the latter injury is so extensive as to cause recurrence of the dislocation after its reduction.

The diagnosis of injuries of vessels and nerves has been discussed on pp. 379 and 380.

Treatment of Dislocations of the Shoulder.—A recent dislocation should be reduced as soon as possible after the accident. On account of the contraction of the muscles surrounding the joint it is best to administer an anesthetic. The methods chiefly employed at the present day are: (1) by manipulation; (2) by traction or extension.

1. **Reduction by Manipulation.**—The method almost universally practised is that of Kocher,[25] which was first suggested by him in 1870. The best position for reduction is with the patient lying upon his back. The method is divided into four steps: (1) The injured arm (Fig. 293) is grasped just above the condyles of the humerus with one hand, while the other hand grasps the patient's wrist. The arm, which is in an abducted position, is flexed to a right angle and slowly carried backward until it touches the side of the body.

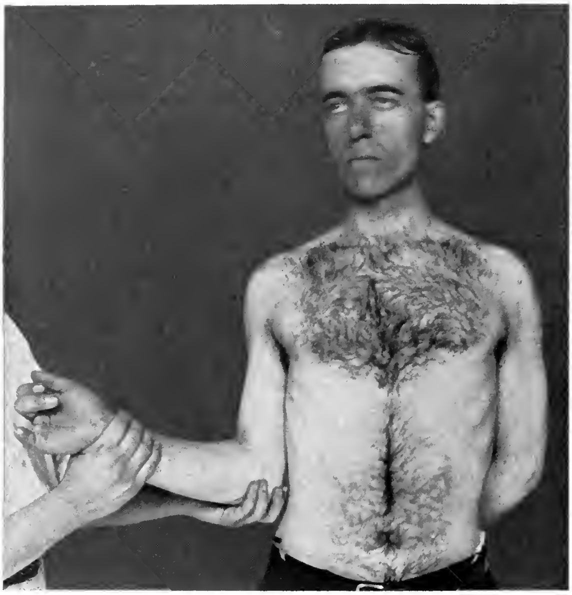

Fig. 294.—Second Step in Reduction of Dislocation (Subcoracoid) of Shoulder-joint by Kocher's Method. The elbow is held closely to the side of the chest; forearm is rotated outward as far as possible.

(2) The arm is now rotated slowly outward until the forearm points directly outward from the body (Fig. 294), when a distinct resistance can be felt. During this second step the elbow is still grasped by one hand of the surgeon and the wrist by his other hand.

(3) While external rotation of the arm and flexion of the elbow are still maintained, the elbow is gradually adducted by moving it forward or forward and slightly inward until the arm is nearly horizontal.

(4) The elbow having been raised as high as it will go, the arm is gradually rotated inward until the hand touches the opposite side of the thorax (Fig. 295).

All of the steps should be gradually carried out and no force employed on account of the danger of producing a fracture at the surgical neck. The Kocher method is based upon the exact knowledge of the pathologic conditions, and is the most perfect for this reason.

The posterior part of the capsule and the scapular tendons inserted therein are usually untorn and stretched tightly across the glenoid fossa. Rotation outward relaxes this structure and removes it from the fossa, while the rent in the capsule gapes; but, owing to the fact that the upper and lower margins of the opening are still tight, the head of the humerus remains fixed against the neck of the scapula until the elbow is carried forward and raised. The upper part of the capsule then relaxes, and the lower part, which remains tense, guides the head of the bone into the joint.

Reduction is recognized by a click when the head slips into the glenoid cavity.

The outline of the normal convexity of the shoulder is immediately restored, and the head of the bone can be moved in all directions.

In the majority of cases the method of Kocher will be successful if correctly applied. If it is impossible to reduce the dislocation by this method, traction should be employed.

2. **Traction** may be applied in different ways. One of the simplest is to make traction downward and outward. The arm is grasped above the elbow and steady traction made in a downward and outward direction. The arm is now gradually abducted until it is nearly or quite at right angles with the body. Pressure is then made over the head in the axilla.

Fig. 295.—Third Step in Kocher Method of Reduction of Subcoracoid Dislocation of Shoulder-joint.
External rotation, as shown in Fig. 294, still being maintained, the elbow is brought inward toward the middle line.

Stimson[26] has suggested a method of traction in which the muscular resistance is overcome by continuous extension by means of weights attached to the arm. The patient is laid upon a cot or table, in which an opening is cut through which the arm is passed. The cot is raised upon blocks so that the arm will hang free of the floor, and a weight of ten pounds is attached to the wrist or elbow. Ten pounds are added at intervals of from one to two minutes up to forty pounds. In from five to fifteen minutes the parts are sufficiently relaxed and the head is advanced toward the glenoid cavity by adducting the arm against the fist placed in the axilla. If it is absolutely impossible to reduce the dislocation, an arthrotomy is indicated and the obstacle to reduction removed.

The after-treatment of a simple dislocation is important. After reduction, the axilla and elbow should be freely powdered with talcum and a Velpeau bandage applied. At the end of the first week this dressing is removed and massage and light passive motion given for ten minutes twice daily. In the interval the arm should be kept in a sling. The range of passive motion is gradually increased during the second and third weeks. At the beginning of the fourth week light active movements are permitted; the sling is discarded after the fourth week. Active movements are now encouraged and aided by some form of gymnastic apparatus (Fig. 75).

FIG. 296.—FOURTH STEP IN KOCHER'S METHOD OF REDUCTION OF SUBCORACOID DISLOCATION OF THE SHOULDER.

The elbow having been kept close to the chest-wall until it reached the middle line, the forearm still being rotated outward. By a quick movement the arm is raised until the hand is brought over to the opposite shoulder.

The treatment of *dislocations which are complicated by fractures* requires special mention. The dislocation should be reduced at the earliest possible moment.

Jones has shown by radiographic examination that the head is so displaced in many cases and the callus so exuberant that the arm is not only seriously restricted in its movement, but painful pressure symptoms result.

An anesthetic should always be administered and every method should be tried in order to reduce the head before performing an operation.

An excellent method in fractures of the surgical or anatomic neck is to make traction upon the fully abducted limb (*i. e.*, held vertically), while pressure is made upon the head with the fingers in the axilla. If these efforts at reduction fail, the best operation is that of McBirney. An incision is made over the outer anterior aspect down to the upper fragment and a hole drilled into the latter. A stout hook is then inserted and direct traction made upon the upper fragment in the proper direction. Four successful cases have been reported.

The treatment of injuries of the vessels and nerves is discussed in the chapters on those subjects.

The Treatment of Unreduced or Ancient Dislocations.—Attention has already been called to the great dangers attending efforts at reduction of old unreduced dislocations. These dangers are fracture of the surgical neck, injury of the axillary artery or one of its larger branches, or injury of the axillary vein, and injury of the nerves of the brachial plexus. The safest method of treatment of an unreduced dislocation is by arthrotomy. A number of different incisions and methods of operation have been suggested.

E. W. Andrews[27] has recently advocated the following technic: An incision is made from the clavicle downward across the front of the shoulder into the axilla. The pectoralis major tendon is divided close to its insertion, thus exposing the axillary vessels and brachial plexus. The pectoralis minor is not cut unless the head of the humerus and the vessels have been forced under it. Great care is employed in separating the vessels and nerves from the adhesions, and they are then pulled aside. Traction is made by an assistant upon the flexed forearm and the arm rotated inward and outward until the adhesions are seen to permit a free range of motion of the head. The head is returned to the glenoid cavity after the latter has been cleared of scar tissue. If loose fragments of bone are present, they should be removed. If the tendon of the biceps is the cause of the irreducibility, it should be replaced in its proper position. At times[29] reduction cannot be accomplished until all the muscles attached to the tuberosities have been severed.

If the dislocation has been irreducible on account of a fracture of the anatomic or surgical neck, excision of the head is to be preferred through the Ollier incision. This incision extends from the tip of the coracoid process obliquely downward and outward along the anterior border of the deltoid for 8 to 10 cm.

The after-treatment of an arthrotomy for an unreduced dislocation requires immobilization of the limb for two weeks, after which time passive motions are gradually begun.

Treatment of Habitual or Recurrent Dislocation.—In the description of the pathology of this condition in the shoulder-joint on p. 382 three chief causes for the recurrence were mentioned: 1. A tearing off of the muscles attached to the greater or lesser tuberosities or an avulsion of these processes themselves. 2. A fracture with separation of portions of the inner edge of the glenoid cavity. 3. A relaxation of the capsule.

The best method of treatment of a recurrent dislocation is by arthrotomy.

After the joint has been exposed by a method such as that of Andrews or of Perthes,[7] the further steps depend upon the anatomic conditions found. If the capsule is relaxed, it can be narrowed by sutures of some absorbable material.

This method will not be found satisfactory in cases in which the recurrence is due to tearing off of the muscles attached to the tuberosities. Perthes has recently reported two cases with excellent results in which he reattached the torn-off muscles by small U-shaped nails in one case, and closed a gap in the edge of the glenoid cavity in a second case. Hildebrand[6] recommends deepening the glenoid and removing a portion of the posterior edge so as to flatten it. No operative treatment seems advisable in habitual dislocations due to syringomyelia.

DISLOCATIONS OF THE ELBOW.

Frequency and Classification.—Dislocations of this joint are next in frequency to those of the shoulder and fingers. They occur more often in children and young adults than in later life, and most frequently in males. The dislocation may involve both bones of the forearm, or either one of them alone, and the displacement may be in several directions. The following classification is the most generally accepted one:

1. Dislocations of both bones of the forearm:
   (*a*) Backward (backward and outward or backward and inward).
   (*b*) Lateral (incomplete inward and outward or complete outward).
   (*c*) Forward (with or without fracture of the olecranon).
   (*d*) Divergent (anteroposterior and transverse).
2. Dislocations of the ulna alone (backward and upward).
3. Dislocations of the radius alone (forward, backward, and outward).

Dislocation of Both Bones of the Forearm Backward.—This is the most frequent form of dislocation at the elbow. The manner in which it is usually produced is by falling upon the palm of the outstretched hand, the elbow being completely extended. The tip of the olecranon becomes fixed just above the trochlear surface of the humerus, so that the elbow is hyperextended. In the majority of cases the first effect of the action of the force after falling upon the extended or partially flexed forearm is to abduct the forearm. This tears the internal lateral ligament and frees the ulna. The radius and ulna can now slip past each other, the external lateral ligament being torn or detached in the movement, and the head of the radius tearing off the corresponding part of the capsule and adjoining periosteum as it slips up behind the condyle. The displacement varies according to whether one or both ligaments are torn, and also to the degree of abduction or adduction of the forearm.

Pathology.—The internal lateral ligament is always torn, usually at its insertion to the humerus, and the tear extends along the anterior ligament. The external lateral ligament is also torn and detached from the humerus. The greater the degree of abduction or adduction of the forearm during the fall, the more extensive will be the tearing off of the lateral ligaments. The flexor muscles of the hand are sometimes torn from the humerus. The brachialis anticus may be torn across and interposed between the displaced articular surfaces. The tip of the coronoid process may rest against the lower and posterior surface of the trochlea, and the radius still remain in contact with the under surface of the capitellum. Some writers (Hoffa) suggest calling this form of backward dislocation an incomplete one, to distinguish it from those cases in which both bones are entirely dislocated. Such a distinction is confusing and superfluous. The wrist points inward or outward, according to whether the radius is more displaced than the ulna or vice versâ.

The complications are injuries of the adjacent vessels and nerves and the occurrence of fractures of the humerus, ulna, or radius. In 1889 Molitor was able to collect eleven cases of laceration of the brachial artery. Injuries of the nerves are quite rare. Several cases of injury of the radial nerve have been reported. The most frequent fracture in connection with a dislocation backward of the elbow is a tearing off of the coronoid process. Partial fracture of the head of the radius has been observed in a number of cases, often associated with a fracture of the coronoid process. Fractures of the external epicondyle are quite frequent. The tip of the internal epicondyle is often torn off. If the fragment is large, it remains attached to the internal lateral ligament and is displaced upward and backward. Fractures of the olecranon, shaft of the ulna, and the radius are infrequent complications.

The dislocation may become a compound one if the lower end of the humerus is forced through the skin of the front of the elbow.

Diagnosis.—Unless the patient is seen some hours after the injury, when the swelling is so extensive as to obscure the outlines, a diagnosis can be made by inspection aided by palpation.

The elbow is semiflexed, the forearm being either slightly supinated or held midway between supination and pronation. If there is but little swelling, one can notice an increase in the anteroposterior diameter of the elbow. The ulna and radius are very prominent at the back of the joint and the lower end of the humerus projects in front. Voluntary extension and flexion are possible, to a slight degree, but there is abnormal lateral mobility. The forearm appears shortened. Upon palpation of the three bony points at the back of the elbow (Fig. 115) the tip of the olecranon is displaced upward above the level of a line joining the two condyles when the limb is extended. In a supracondyloid fracture of the humerus the two condyles and the olecranon are not changed in their normal relation to each other. The olecranon process of the ulna and the head of the radius can be easily felt and often seen under the skin, lying in a plane which is considerably behind that of the humerus, as can be determined by comparing them with the opposite elbow. The outlines of the

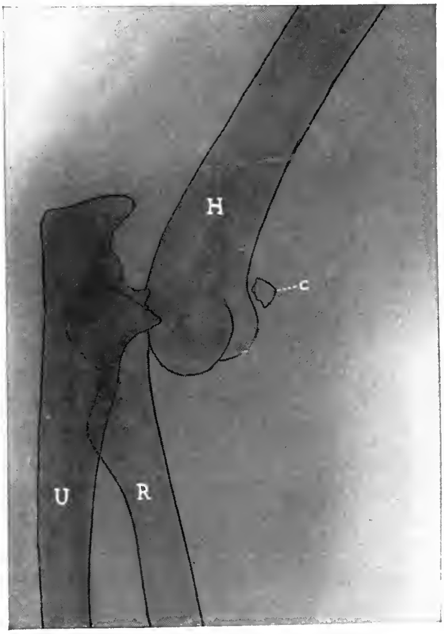

Fig. 297.—Skiagraph of Case of Dislocation Backward of Both Bones of Forearm.

U, Ulna; R, radius; c, broken-off coronoid process of ulna; H, shaft of humerus. Note in the shadow the obliteration of the normal depression above the coronoid process (see text).

lower end of the humerus can be recognized by palpation over the front of the elbow.

Fracture of the olecranon and epicondyles can be recognized by manipulation. If, after reduction, the displacement readily recurs, a fracture of the coronoid process should be suspected. Such an apparent recurrence may also be present in a fracture of the internal condyle with displacement of the fragment and dislocation of the radius backward.

Treatment.—Reduction is easily effected in the majority of cases. The most frequent causes of non-reducibility are the interposition of bone fragments, portions of torn-off muscle, and the capsule. In cases of over six weeks' standing there is but little probability of reduction.

The method of reduction most commonly employed is that first suggested by Sir Astley Cooper. The surgeon presses backward against the lower end of the humerus with his knee, while he grasps the patient's wrist and forcibly but slowly bends the forearm. The best method of re-

Fig. 298.—Method of Reduction of Backward Dislocation of Both Bones of the Forearm at the Elbow.

Traction is made upon the flexed forearm, one hand being placed close to the elbow and the other around the wrist. The region just above the elbow steadied by the hands of an assistant (see text).

duction is to administer an anesthetic and hyperextend the forearm while it is supinated, the arm itself being steadied by the hands of an assistant. Moderate traction then draws the forearm gently forward, while the other hand seizes the elbow and controls the position of the parts. The forearm can now be flexed without any obstacle, and the normal relations at the back of the elbow are reëstablished.

The arm should be maintained in a flexed position upon a posterior molded or a metal splint. Light passive motion can be safely begun during the third week, and all retentive apparatus discarded at the end of four weeks. More vigorous passive and active motions are then employed. Fractures of the coronoid process or of the tip of the epicondyles require no special treatment. In fractures of the olecranon the fragments can be approximated by strips of adhesive plaster until the end of the third week, when the joint can usually be extended.

Lateral Dislocations of Both Bones of the Forearm.—Pure dislocations outward or inward are rare. In the majority of reported cases the displacement has been backward as well as inward or outward. The dislocation may be incomplete or complete. The incomplete form is the more frequent, is usually of the outward variety, and is often combined with a fracture of the internal epicondyle. The injury follows a fall upon the hand while the arm is extended, or, more often, it is the result of a forcible abduction or adduction of the forearm.

Diagnosis.—In a complete outward dislocation, of which about twenty-five cases have been reported, the diagnosis can be best made by palpation of the relations of the bones. The forearm seems to lie parallel to the humerus. The olecranon and head of the radius can both be plainly felt well above and to the outer side of the external condyle. In the incomplete outward variety (the most frequent of the lateral dislocations) the prominence formed by the head of the radius is distinctly seen and felt on the outer side of the external condyle.

The epitrochlea, if broken off, may be felt and moved between the fingers.

Incomplete inward dislocations are rare. Flexion and extension are quite free. The olecranon projects beyond the epitrochlea and its articular surface can be felt. The head of the radius can be felt below the empty olecranon fossa.

Treatment.—Reduction is effected by traction upon the forearm, while it is held in an overextended position, followed by flexion. While traction is being made the ulna is pushed outward in an inward dislocation.

In the outward variety (usually incomplete) pressure in an inward direction is made upon the head of the radius during traction and flexion of the forearm.

If reduction cannot be effected, an arthrotomy should be performed and the obstacle, which is often a detached fragment of bone, removed.

Forward Dislocation of Both Bones of the Forearm.—Only twenty-five cases of this variety of dislocation have been reported. It is frequently associated with a fracture of the olecranon. The cause is a fall upon the flexed elbow, rarely traction or a fall upon the hand.

Diagnosis.—Upon palpating the back of the elbow the olecranon is found to be absent unless it has been simultaneously broken. If the latter complication exists, the upper fragment can be felt. The outline of the lower end of the humerus can be readily felt at the back of the elbow. In the incomplete form the olecranon is prominent below the humerus when the elbow is flexed. In the complete form the tip of the olecranon is found in front of the lower end of the humerus.

Treatment.—Reduction is effected by pressing or pulling the upper end of the forearm downward or backward.

Divergent Dislocation of the Bones of the Forearm.—There are two varieties—(*a*) an anteroposterior, in which the ulna passes up behind and the radius in front of the humerus. Fourteen cases of this form have been published. (*b*) The transverse variety, in which the radius passes to the outer and the ulna to the inner side of the humerus. The diagnosis can be readily made by palpation. Each bone must be reduced separately—the ulna by hyperextension and traction and the radius by direct pressure.

Dislocations of the Ulna Alone.—Isolated dislocations of the ulna are comparatively rare and are only in a backward, inward, or forward direction.

In the backward variety the most common form is that in which the coronoid process has cleared the trochlea. It is known as the incomplete form, to distinguish it from the complete, in which the coronoid rests upon the olecranon fossa. The injury occurs after a fall on the ulnar side of the hand or forearm. It may also follow forcible adduction or pronation.

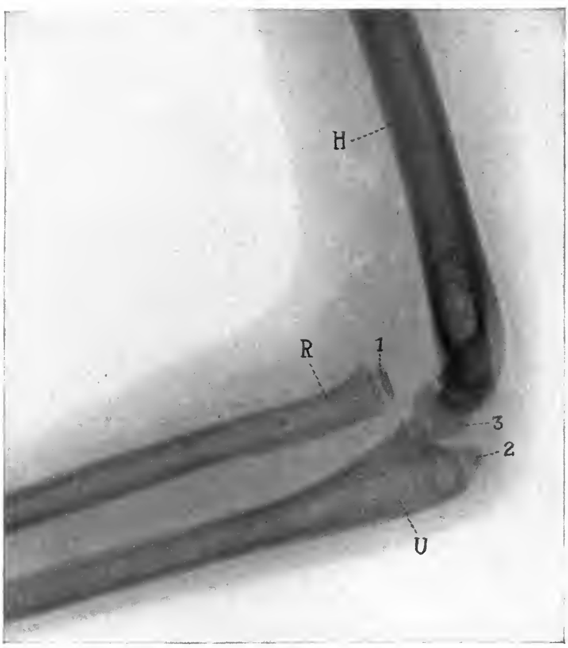

Fig. 299.—Forward Dislocation of Radius in a Boy of Ten.

Compare with the normal elbow of same patient shown in Fig. 47, p. 91. R, Shaft of radius; U, shaft of ulna; H, shaft of humerus. 1, Upper epiphysis of radius (capitellum); 2, upper epiphysis of ulna, which forms the olecranon process; 3, lower epiphysis of humerus

Diagnosis and Treatment.—The symptoms are almost the same as those of a posterior dislocation. The olecranon lies considerably above the horizontal line joining the epicondyles, and is quite prominent. The head of the radius can be felt to rotate in its normal place.

The elbow is in varus position, and the ulnar side of the forearm is shortened. Reduction can be effected by overextension and traction. The inward and forward varieties are very rare, only two cases of each having been reported.

Dislocation of the Radius Alone.—This occurs more frequently than an isolated dislocation of the ulna. It may occur in a backward, outward, and forward form. The latter is the most common and is due to a blow upon the head of the radius or to a fall upon the pronated forearm. The injury is frequently associated with a fracture of the upper third of the ulna.

Diagnosis.—Both active and passive movements of the elbow, especially flexion, are painful and limited. Upon examining the back of the elbow in the systematic manner already referred to, the head of the radius is not found in its normal position. Instead of the head, one finds a depression on deep palpation; the head itself is felt in front of the lower end of the humerus on the radial side of the bend of the elbow.

In older cases, when the swelling has disappeared, the head of the radius may project considerably above the level of the surrounding tissues. In the cases which are associated with fracture of the ulna, the latter can be recognized by palpation of the deformity when the finger is passed along the back of the ulna, and by the presence of abnormal mobility.

Treatment.—Reduction is best effected by traction and pressure backward over the dislocated head. If reduction is impossible on account of an interposed capsule, an arthrotomy is indicated. At times, especially in old unreduced cases, it is necessary to resect the head.

Subluxation of the radius, or "*pulled elbow,*" occurs in a young child after lifting it by the forearm or pulling upon the latter. There is no palpable or visible displacement of the radius. The child will not use the arm, and it either hangs by its side or is supported by the other one. There is pain on pressure over the head of the radius, and the child resists any rotary movements of the forearm, especially supination. In the majority of cases a separation can be felt between the lower end of the humerus and the head of the radius. After forced supination a slight click is heard and the child uses the arm freely again.

Treatment of Ancient or Unreduced Dislocations of the Elbow.—The causes of irreducibility of elbow dislocations are: 1. The capsule. 2. Interposition of muscle, especially the brachialis anticus. 3. Interposition of fragments of bone. Of these, the last-named cause is the most frequent obstacle to reduction. The fractures are usually of one or both condyles of the humerus, especially a tearing off of the external epicondyle and of the epitrochlea.

The ends of the displaced bones become surrounded with cicatricial tissue in an unreduced dislocation. New bone formation in the shape of osteophytes takes place in this connective tissue, and may be one of the obstacles to reduction of the dislocation. The capsule seldom offers much resistance to reduction, owing to the fact that in the majority of cases it has been extensively torn.

The pathologic changes which take place within the first few months after failure to reduce a dislocated elbow are so extensive that it is useless to attempt reduction by manipulation. It is far better to perform an arthrotomy and reduce the displacement. Although arthrotomy for unreduced dislocation of the elbow was performed by Blumhardt in 1847, it was first employed as a routine measure by Nicoladoni,[29] who reported 2 cases in 1885. In 1903 Blum[30] was able to collect 64 cases. Weber[31] added 2 more cases operated upon by himself. Arthrotomy can be performed by one of two methods, viz., that of Stimson[32] or of Kocher.[33] Stimson advises an incision over the head of the radius and the mass of new bone. The latter is freely chiseled away and the capitellum exposed. Through this incision the sigmoid fossa is cleared of fibrous tissue. A second incision is made over the inner side of the elbow, the ulnar nerve drawn forward, and the olecranon freed. If the epitrochlea is broken off and displaced upward and backward, it must be detached from the humerus. The cleaning of the sigmoid cavity is then completed, and the attachments of the olecranon thoroughly divided. Reduction can now be made. At times it is necessary to partly divide the flexor muscles close to the humerus.

Weber,[31] in a recent paper upon this subject, strongly recommends the Kocher incision. The elbow being held in a flexed position, an incision shaped like a fish-hook is made over the back of the elbow. The incision begins along the outer border of the humerus and runs downward until it reaches a point about two inches below the olecranon, when it curves inward. The triceps is separated from the muscles attached to the external condyle. The radius and ulna are now freed, and the dislocation reduced. Detached bone fragments, being the chief obstacle to reduction, should be removed.

The entire external condyle and a portion of the trochlea can be removed without interfering with the function of the joint. If the internal condyle is broken off and displaced, it should not be removed. Resection is to be preferred under these circumstances.

After reduction the joint should be immobilized for three weeks, after which light passive motion can be begun. The results obtained after operative reduction have been very satisfactory, almost perfect joint function being secured.

DISLOCATIONS AT THE WRIST.

Dislocations at the wrist may take place in four locations: (1) In the lower radio-ulnar joint; (2) in the radiocarpal joint; (3) of the carpal bones, and (4) carpometacarpal joint.

Dislocations of the Lower Radio-ulnar Joint.—This is a very rare form of dislocation at the wrist. Only 35 cases have been reported. Of these, 20 were in a forward and 15 in a backward direction. In the forward variety the injury follows direct violence to the lower end of the ulna, or it may occur while the hand was supinated. The diagnosis can be made by inspection and palpation.

The lower end of the ulna is prominent in front and there is a depression at the back of the wrist. The displacement is corrected by direct pressure upon the ulna and counterpressure on the radius. In the backward variety the injury follows an excessive pronation of the wrist. The diagnosis can be made from the projection of the lower end of the ulna at the back of the wrist. Reduction is effected by pressure upon the radius.

Dislocation in the Radiocarpal Joint.—This joint is also seldom dislocated. Forty-three authentic cases have been collected by Tillmanns and Hecht. It may take place in a backward or forward direction.

(a) **Dorsal or Backward Dislocations.**—This usually follows forcible dorsal flexion, such as a fall from a height upon the palm of the hand. It resembles a Colles fracture in appearance, but differs from it by the fact that the prominence on the front of the wrist extends further down toward the hand in dislocation than in fracture. There is a prominence at the back of the wrist, but it ends more abruptly than in a Colles fracture. By palpation one can outline the convex outline of the carpal bones upon the back of the wrist. Reduction can be effected by traction upon the hand and direct pressure upon the carpus.

(b) Dislocations Forward.—The most frequent cause is a fall upon the hand while it is strongly flexed. There is a marked depression on the back of the wrist, the upper border of which is formed by the prominent lower ends of the radius and ulna. There is a corresponding prominence with convex upper margin upon the front of the wrist formed by the displaced carpus. Reduction is easily effected by traction upon the hand and countertraction upon the forearm while direct pressure is made upon the displaced carpus.

Dislocations of the Carpal Bones.—**(a) Dislocations in the Mediocarpal (Intercarpal) Joint.**—Dislocations in the joint between the first and second rows of carpal bones are extremely rare. Two cases of backward dislocation have been reported by Maissoneuve and Schmidt, and 4 of forward dislocation by Després, Richmond, Tillmanns, and Bahr.[8] The symptoms of the dorsal form resembled those of an ordinary Colles fracture of the silver-fork type of deformity, but the swelling upon the back of the wrist began a little lower down. In the forward variety the deformity resembled that of a Colles fracture of the gardener's spade (p. 205) type of deformity, but the prominence was nearer to the hand and the latter was slightly abducted. In both varieties the dislocations follow a fall upon the hand. Reduction is effected by flexion or extension of the hand, aided by traction and pressure over the displaced distal carpal row.

(b) Isolated Displacement of the Carpal Bones.—Although cases have been reported of isolated dislocation of the majority of the carpal bones, one need only consider dislocation of the semilunar and scaphoid. The recognition of these injuries is of great importance, since many cases of sprains or contusions of the wrist are in reality either simple fractures of the scaphoid (p. 210) or anterior dislocations of the semilunar bone. The two injuries are frequently combined, and in such cases the proximal fragment of the scaphoid is usually dislocated forward with the semilunar bone.

Codman and Chase[34] have collected all of the cases of these injuries which have been published up to 1905 and added a number of their own.

Anterior dislocation of the semilunar bone should be recognized, according to these authors, clinically, even without the *x*-ray, by the association of the following symptoms, viz., (*a*) the history of an injury of considerable violence to the extended or twisted wrist; (*b*) a silver-fork deformity, the posterior prominence of which corresponds with the head of the os magnum and between which and the lower end of the radius is found a groove representing the position formerly occupied by the now anteriorly dislocated semilunar; (*c*) a tumor under the flexor tendons of the wrist just anterior to the lower end of the radius; (*d*) a shortened appearance of the palm as compared to the other hand; (*e*) stiffness of the partially flexed fingers, motion of which, either active or passive, is painful; (*f*) the persistence of the normal relation of the styloid processes of the ulna and radius, and the existence of shortening of the distance from the radial styloid to the base of the first metacarpal.

Recent dislocations of the semilunar may be reduced with good result even after the fifth week by hyperextension followed by hyperflexion over the thumbs of an assistant, held firmly in the flexure of the wrist on the semilunar. Irreducible dislocations demand an excision of the semilunar and the whole or a portion of the scaphoid if there is a coincident fracture of the latter.

Dislocations of the Carpometacarpal Joints.—These are very rare injuries. Burk, quoted by Hoffa, has collected 23 published cases, excluding those of the thumb. Carette, in 1894, was able to collect 27 cases of dislocation of the first metacarpal, and Stimson states that of 73 dislocations of the carpometacarpal joint occurring in the Hudson Street Hospital of New York between 1894 and 1903, almost all were cases of backward dislocation of the first or metacarpal bone of the thumb.

Dislocations in the carpometacarpal joints may occur in a backward, forward, or divergent direction. The joint most frequently involved is that of the thumb, and the displacement is almost invariably in a backward direction. The backward dislocation of the first metacarpal is quite frequently incomplete. The cause may be a forced flexion of the thumb into the palm of the hand, or its forced movement in the opposite direction, or direct violence upon the thenar eminence. The dorsal edge of the base of the metacarpal bone of the thumb can be seen and felt as a prominence on the back of the thumb, between the two long extensor tendons. In the complete form this dorsal prominence is very marked. The injury can be differentiated from a fracture of the first metacarpal, known as Bennett's fracture, by the signs given on p. 215.

Cases of isolated dislocations either in a forward or backward direction of the other metacarpal bones have been reported, but the number is small as compared with those of isolated dislocation of the first metacarpal. In the forward variety the palm seems filled out by an indistinct, deep-seated bony mass, and there is a corresponding depression upon the back of the hand. If there is much swelling present in all these dislocations, a diagnosis can be made only by the *x*-ray.

A few cases have been reported of simultaneous dislocation of the four inner metacarpal bones and also of simultaneous dislocation of all five metacarpals. Only one case (Schütz) has been published of a divergent dislocation, *i. e.*, where one metacarpal was displaced forward and the adjacent one backward. Reduction is effected in recent cases by traction upon the hand while pressure is made over the base of the dislocated metacarpal bone.

DISLOCATIONS OF THE METACARPOPHALANGEAL JOINTS.

These occur relatively rarely in the second to the fifth fingers, but are quite common in the thumb.

1. **Dislocation of the Thumb.**—This, in its typical form, is always in a backward direction, *i. e.*, the base of the first phalanx resting upon

the head of the first metacarpal bone. If the articular surface of the phalanx simply rests against the posterior margin of the head of the metacarpal bone, the dislocation is said to be an incomplete one.

If the articular surface of the phalanx leaves that of the metacarpal bone entirely and rests upon the back of the head, the dislocation is called a complete one. The most frequent cause is hyperextension of the first phalanx of the thumb. The proximal end of the phalanx is to be seen and felt as a projection upon the dorsum of the thumb, causing a step-like or bayonet deformity. The head of the first metacarpal bone is very prominent upon the palmar surface of the thumb. The axis of the first phalanx forms almost a right angle with that of the metacarpal bone (Fig. 300), while the second phalanx is flexed upon the first. The thumb is abducted. If the lateral ligaments are not torn, the thumb is decidedly rigid, but if these ligaments are torn, it is quite movable in all directions. The forward variety is rare, and the deformity is the reverse of the backward one.

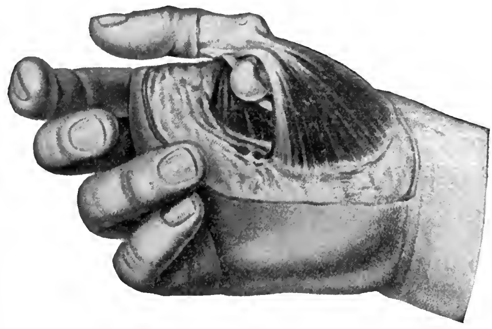

Fig. 300.—Backward Dislocation of First Phalanx of Thumb.
Note head of metacarpal and how it is held by adductor brevis and flexor longus pollicis (Helferich).

Treatment.—The chief interest lies in the difficulty of reduction. Unless the deformity is reduced at an early period, it interferes greatly with the use of the thumb. The obstacles to reduction are—(*a*) the interposition of the sesamoid bones; (*b*) or of the torn edge of the anterior ligament, which becomes closely drawn behind the head of the metacarpal bone, and (*c*) the tension of the flexor longus pollicis tendon, which surrounds the neck of the first metacarpal. The last named is apt to form an insurmountable obstacle to reduction if the articular surface of the head of the metacarpal is thickened on its ulnar side and the tendon catches

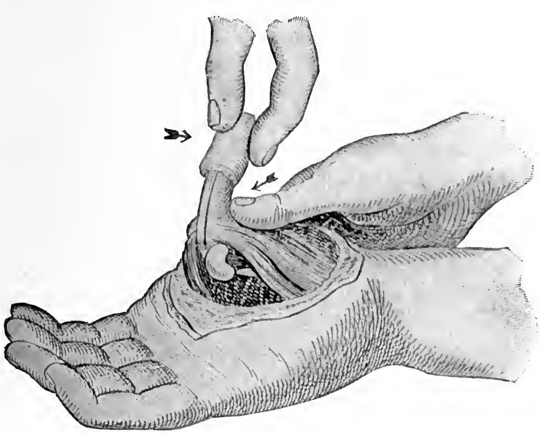

Fig. 301.—Proper Method of Reduction.
Dorsal flexion of thumbs (true extension); traction through dorsal pressure by thumbs so that base of phalanx is advanced over head of metacarpal (Helferich).

on this thickened rim. Reduction can usually be effected without the use of force. The thumb is hyperextended while traction is made upon it. Still maintaining the traction, the thumb is quickly flexed into the palm, direct pressure being applied over the base of the first phalanx and the thumb pushed directly forward (Fig. 301). If the ligament has caught behind the head, it may sometimes be freed by rotating the phalanx while pressing it downward. If reduction is found to be impossible, arthrotomy should be performed by a short incision over the head of the metacarpal on the palmar surface, the edges retracted, and the ligament incised, or the long flexor tendon freed from the back of the metacarpal bone. In old cases resection of the head of the metacarpal bone may be necessary.

Forward dislocations of the thumb are much rarer and less difficult to reduce. The phalanx projects in front of the metacarpal bone, while the head of the latter is prominent upon the back of the thumb, the bayonet deformity being the reverse of that seen in the backward variety.

Reduction is readily effected by traction and forced flexion, aided by downward pressure over the base of the phalanx.

Dislocations at the metacarpophalangeal joints of the remaining fingers are quite infrequent as compared to those of the thumb. The index- and little fingers are usually involved. The displacement is dorsal, the injury often being compound. It follows hyperextension of the finger. The dislocation must be differentiated from fracture of the neck of the phalanx with displacement of the distal phalanx (p. 217). Reduction is effected by traction upon the finger aided by flexion and direct pressure over the base of the phalanx.

Dislocations at the Interphalangeal Joints of the Fingers.—Dislocations of the second and third phalanges may occur as the result of hyperextension or hyperflexion or forcible adduction or abduction of the finger. The displacement may be backward or forward. The diagnosis is readily made by inspection and palpation aided by the *x*-ray. The base of the dislocated phalanx lies either upon the dorsum or upon the palmar aspect of the proximal one. The finger may be flexed or extended or there is lateral deviation. A differentiation from a fracture of the phalanx usually presents no difficulty (p. 217).

Reduction is easily effected by extension and direct pressure over the base of the dislocated phalanx. If reduction is impossible, it is best to resort to arthrotomy.

DISLOCATIONS OF THE RIBS.

Dislocation of a rib may occur at its articulation with a vertebra behind, or at the junction of its costal cartilage with the sternum, in front. A third form of dislocation is where the anterior end of one of the ribs which articulates by means of cartilage with the adjacent ones is dislocated. This can only occur in the eighth, ninth, and tenth ribs. The second form of dislocation can only occur in the sternal ends of the first seven ribs. Both of these forms of dislocations of the ribs are extremely rare. They are always the result of direct violence.

Dislocation of the costovertebral joint is a frequent accompaniment of fractures of the spine. The end of the rib may cause a perforation of the pleura, with laceration of the intercostal artery and severe hemorrhage into the pleural cavity. The diagnosis can at times be made by discovering the abnormal mobility of the vertebral end of the rib, by palpation and by the absence of crepitus. In dislocations at the costosternal junction the costal cartilage is displaced forward and can be readily felt. In dislocation of the cartilaginous end of the eighth, ninth, or tenth rib upon its fellow the diagnosis can be made from the presence of abnormal mobility and of deformity. Reduction is easily effected by pressure in an inward direction. The ribs should be immobilized with strips of adhesive plaster.

DISLOCATIONS OF THE PELVIS.

It was formerly believed that pure separations of the pubic or sacro-iliac symphyses could occur, and Malgaigne suggested the following classification:

1. Dislocations of the pubic symphysis.
2. Dislocations of the sacro-iliac symphysis.
3. Dislocations of these two symphyses or of the ilium.
4. Dislocations of the two sacro-iliac symphyses.
5. Dislocations of the two sacro-iliac and of the pubic symphyses simultaneously.
6. Dislocations of the coccyx.

The majority of writers now believe that the above classification of Malgaigne should be dropped. A diastasis or dislocation at one of the symphyses is extremely rare, and it is impossible to recognize it during life. The cases which were formerly described as pure dislocations are now recognized as having been cases of fractures (p. 219) close to the symphyses, with dislocation of the fragments, as Stolper[35] has recently pointed out, resembling in type the fracture-dislocations of the spine. Dislocation of the coccyx is the only one of the classification which is a true dislocation.

DISLOCATION OF THE HIP.

Dislocation of the hip is not of frequent occurrence, forming about 2 per cent. of all dislocations. The period of life during which the largest number of cases occur is between the ages of twenty and fifty. It is much more common in men than in women. Of all the forms, the backward occur more often than all the others. The left hip is more frequently involved than the right.

Only 32 cases of simultaneous dislocation of both hips have been reported, the last case being that of Lewis.[36] Compound dislocations are very rare, only 10 cases having been reported.

The weakest part of the capsule of the hip-joint is below and behind, and it is through an opening in this portion that the head usually escapes. The capsule is greatly strengthened in front by the Y ligament of Bigelow.

The classification which is almost universally accepted is as follows:

1. Backward dislocations.
   (*a*) Dorsal (including the iliac and ischiatic).
   (*b*) Everted dorsal (including the supraspinous).
2. Downward and inward dislocations.
   (*a*) Obturator.
   (*b*) Perineal.
3. Forward and upward dislocations.
   Suprapubic (iliopectineal, pubic, and central or intrapelvic).
4. Upward dislocations (supracotyloid or subspinous).
5. Downward dislocations (on the tuberosity of the ischium).

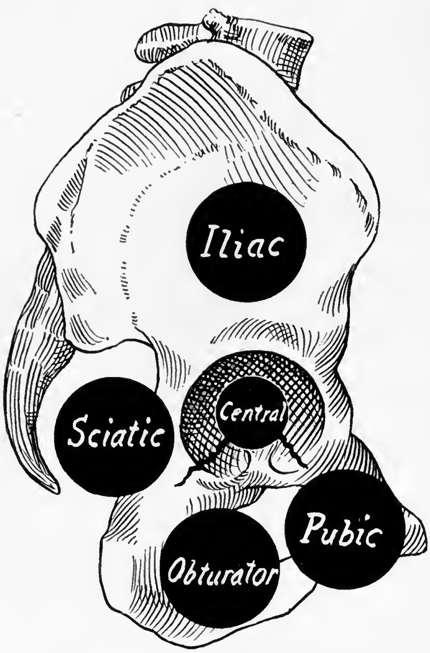

Fig. 302.—Location of Head in Various Forms of Dislocation of Hip.

1. **Backward Dislocations.**—(*a*) *Dorsal Dislocations.*—The head is found lying upon the dorsum ilii, the group including the iliac and ischiatic varieties. In the iliac form the head is above the obturator internus tendon and rests upon the dorsum of the ilium. In the ischiatic or sciatic form the head is below the obturator internus tendon and lies over the sciatic notch.

Mechanism and Pathology.—Dorsal dislocations are in general due to any form of violence which will cause flexion, adduction, and inward rotation of the lower extremity. Whether an iliac or ischiatic dislocation results depends upon the degree of flexion and inward rotation of the limb at the time of injury. If the force acts upon the thigh while it is strongly flexed, the posterior portions of the capsule are torn and an ischiatic dislocation results. If, however, the force acts upon the thigh while it is slightly flexed, but is rotated inward, the outer portion of the capsule is torn and the iliac form follows.

The type of violence leading to a dorsal dislocation is when a heavy weight falls upon the back while kneeling or the limb is fixed while the pelvis is rotated. The latter is the more frequent mode of production, the trunk or pelvis rotating while the limb is fixed.

The capsule is always torn in its lower posterior part. In some cases the capsule is torn completely away from the rim of the acetabulum. The iliofemoral ligament is so powerful that it is never torn, and this fact prevents the head from reaching a higher point upon the ilium. The ligamentum teres is usually torn and may carry a portion of the head with it. The sciatic nerve is rarely compressed, but the gluteal vessels may be considerably displaced or even lacerated. The quadratus femoris is usually torn across. The pyriformis and obturator muscles are often partly or entirely torn across.

Fractures of the rim of the acetabulum are quite often an accompaniment of dorsal dislocations (Fig. 173) and may play an important part in the recurrence of the displacement.

The head and neck of the femur may be split longitudinally, or the neck or shaft of the femur may be broken. In 1889 Kammerer was able to collect 19 cases of fracture of the shaft or upper end of the femur accompanying a dislocation of the hip. In 13 of these the shaft was broken, and in 6 there was a fracture of the neck of the femur. In 12 of the cases the dislocation was of the dorsal variety. The occurrence of fractures of the articular surface of the acetabulum will be referred to under Central Dislocations (p. 421).

Spontaneous dislocations of the hip as the result of disease have been described on p. 386.

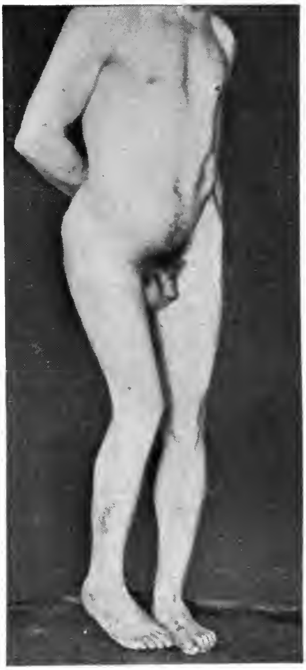

Fig. 303.—Dislocation of Hip, Dorsum Ilii Variety (Macdonald).

Diagnosis of Backward Dislocations.—The signs of the two forms of backward dislocations are practically the same, flexion and inward rotation being more marked in the iliac than in the sciatic variety. The position of the limb is one of adduction and flexion, marked inward rotation, and more or less shortening. The toes of the injured limb rest upon the dorsum of the foot of the uninjured limb (Fig. 303). Measurement of the injured limb shows that the trochanter lies above the Roser-Nélaton line. It is almost impossible to bring the two limbs into a sufficiently symmetric position to enable an accurate measurement of their length to be made, and this is rarely necessary to make a diagnosis. The head of the bone can be indistinctly felt through the gluteal muscles, especially when attempts are made to rotate the limb. Active movement is entirely abolished. The thigh can be flexed passively, but the limb is otherwise fixed. The only conditions which needs to be differentiated are those rare impacted fractures of the neck of the femur (p. 228) which are accompanied by inversion of the limb.

The character of the accident and the palpation of the abnormally placed head, aided by an *x*-ray examination, are the chief points of differentiation.

The presence of a fracture of the rim of the acetabulum should be suspected if reduction of the dislocation is easy and accompanied by crepitus, but recurrence takes place readily. In doubtful cases a skiagraph should always be made (Fig. 173).

If there is accompanying fracture of the neck or shaft of the femur, the signs of these conditions will predominate (pp. 229 and 241), but the head will be found in an abnormal position.

(*b*) *Everted Dorsal Dislocations.*—There are few recorded cases, but it is mentioned on account of the fact that the limb is everted, owing to a laceration of a part of the Y ligament.

2. **Dislocations Downward and Inward.**—In this variety the head of the femur either rests upon the obturator foramen (obturator form) or projects in the perineum (perineal form).

The obturator form is the second in frequency (the dorsal being first) of all of the varieties of dislocation of the hip. The perineal form is quite rare. The most frequent mode of production of both of these forms is that a force acts from behind while the limb is abducted, flexed, and rotated outward. As examples of such a cause may be mentioned falling of a weight, such as a cave-in of earth, upon the patient's back while the limbs are abducted, or a fall from a height while the limbs are spread apart, or the limb being fixed while the trunk falls to one side. The head of the bone comes in contact with the lower and inner portion of the capsule, as the result of the forced abduction and flexion, and penetrates it so that it rests either upon the edge of the obturator foramen or, if the flexion continues, it rests upon the perineum. Up to 1892 only 9 cases of the perineal form had been collected.[37] Seidener[38] reported a case in 1904 in a boy of ten following a fall of thirty feet upon a plank, and Wohlberg[39] reported a case of bilateral perineal dislocation following the fall of a heavy weight while the patient was sitting with the legs abducted. The diagnosis of an obturator dislocation usually presents no difficulties. The limb is slightly flexed, abducted, and rotated outward. The head of the bone can be felt over the obturator foramen from the inner side of the thigh. It is impossible to extend or adduct the limb. There is a depression over the region of the trochanter, and the gluteal region appears flatter.

When the patient stands, the body is bent forward and the weight of the limb rests upon the outer border of the foot. The limb seems lengthened, but careful measurement with both limbs in symmetric positions will fail to show any difference in length. Werner[40] has reported a case in which the head penetrated the obturator foramen as the result of a fracture of the ascending ramus of the ischium.

The diagnosis of the perineal form can be made from the extreme abduction combined with flexion and outward rotation of the limb. The head can be felt through the perineum.

The chief condition to be differentiated is an impacted fracture of the neck of the femur.

A dislocation usually occurs in younger persons than a fracture of the femoral neck, and the history of the accident will be different (p. 227). In both lesions the limb is fixed in abduction and outward rotation. There is usually no flexion deformity in a fracture of the neck, and but little abduction as compared to a thyroid dislocation. The palpation of the head in an abnormal position and the depression over the trochanter will also be important points.

3. **Dislocations Upward and Forward (Suprapubic).**—In this variety the head either rests upon the symphysis pubis at the iliopectineal eminence (iliopectineal form), or less often nearer the symphysis (pubic form).

The suprapubic form is infrequent and follows the action of a force which acts upon the pelvis from behind, driving the head directly forward out of the pelvis. The most frequent mode of production is when the trunk is suddenly forced backward. In some cases the limb has been fixed before the trunk was bent backward. In others it was not. The head penetrates the anterior inner portion of the capsule and escapes through this opening, to rest upon the horizontal ramus of the pubes. The iliofemoral ligament is untorn, but the femoral vessels are pushed inward and may be torn. Considerable pain or numbness along the front of the limb may be present from pressure upon the anterior crural nerve.

The diagnosis in the iliopectineal form can be easily made from the marked outward rotation of the limb. There is but little or no abduction or flexion. The limb is shortened to the extent of an inch, and the head of the femur can be felt in the groin. The femoral vessels may be displaced, and there may be pain along the front of the limb. The pubic form, which is the less common of the two, is characterized clinically by the greater amount of abduction and flexion. It can be differentiated from the obturator form, which it resembles, by the fact that the head rests upon the pubes in the pubic form, while it lies below it in the obturator form.

4. **Dislocations Directly Upward (Supracotyloid).**—These are extremely rare. The head is near the anterior inferior spine, where it is felt as a spheric prominence. The limb is extended, adducted, and rotated inward. Only five unquestioned cases have been reported.

5. **Dislocations Downward (Infracotyloid).**—These are also rare. Wendel,[41] in 1904, was able to collect 16 cases, and Niederle,[42] in 1905, collected 4 more. They occurred after extreme flexion of the thigh. The head escapes over the lower edge of the socket, and rests just below it, upon the outer surface of the body of the ischium. The limb is markedly flexed and adducted. There is slight but distinct shortening, and the head cannot be felt.

6. **Central Dislocations.**—In these the head of the femur is forced into the pelvis (Fig. 302). The injury was formerly considered a rare one, but the use of the *x*-ray has shown this view to be incorrect, as 28 cases have been reported up to 1907. The limb is rotated outward. The deformity can be reduced, but recurs gradually. There is a decrease in the distance between the anterior superior spine and the trochanter. The head can be felt through the rectum. The most exact method of diagnosis is the *x*-ray. Excellent reproductions of such a dislocation are shown in a recent article by Wolff.[43]

Habitual or Recurrent Dislocations of the Hip.—These are extremely rare, only two satisfactory examples having been published—one, a case of Moore, and another, of Bigelow, both quoted by Stimson.

Treatment of Dislocations of the Hip.—An anesthetic should always be given before any attempt is made to reduce a dislocation of the hip. As was stated in the case of dislocation of the shoulder, the older methods of reduction by traction, aided by mechanic appliances, have given way to methods of simple manipulation. The patient should be laid upon a blanket or mattress, which is placed upon the floor or a low table. The pelvis should be steadied by an assistant, who exerts pressure upon the two anterior superior spines (Fig. 304).

Fig. 304.—First Step in Reduction of Dislocation of Hip Backward.

Traction upward upon flexed limb (flexion), the pelvis being steadied by the hands of an assistant placed over anterior superior spine of ilium.

Reduction of Backward Dislocations.—There are three methods in use at the present time:

1. *The Manipulation Method.*—This method was suggested by Nathan Smith in this country in 1831, and by Després in France in 1835. Roser, Busch, and Bigelow contributed much toward placing the method upon a scientific basis by their dissections. The greatest credit belongs to Bigelow, who demonstrated the part played by the Y ligament and based upon it methods of reduction for the different forms of dislocation of the hip. The manipulation method is called the Bigelow method by American and

Fig. 305.—Second Step in Reduction of Backward Dislocation of the Hip.

Abduction of flexed limb, while pelvis is steadied by hands of assistant.

English surgeons. The method known as the Kocher method in Germany is almost identical with that of Bigelow, the only difference being that Kocher recommends inward rotation as the first step in order to relax the capsule.

The steps of the Bigelow method are: 1. Flexion of the thigh to a right angle, while the existing adduction and inward rotation are maintained (Fig. 304). 2. Traction in an upward direction to make the capsule tense and to raise the head to the edge of the acetabulum. 3. Outward rotation while the limb is abducted and allowed gradually to be extended.

2. *Stimson Method.*—An excellent method was suggested by Stimson, of New York, in 1889. The patient is placed face downward upon a table, with his legs projecting so far beyond the edge that the injured thigh hangs directly downward while the surgeon grasps the ankle, the knee being flexed at a right angle. The other limb is held horizontal by an assistant. The weight of the limb now makes the needed traction in

Fig. 306.—Third Step in Reduction of Backward Dislocation of Hip.
The limb, after having been flexed and abducted, is rotated outward, the pelvis still being steadied. The fourth step consists in making extension of the limb.

the desired direction, and the surgeon has only to wait for the muscles to relax and the bone to resume its place without further effort on his part than a slight rocking or rotation of the limb. The everted dorsal dislocation is reduced by first converting it into the dorsal form by flexion, inward rotation, with adduction if necessary.

Reduction of Downward and Inward Dislocations.—*Bigelow's Method.*—1. The thigh is flexed upon the abdomen to a right angle, while the abduction and outward rotation are preserved. 2. Traction upon the flexed limb in an upward direction. 3. Abduction and outward rotation. 4. Extension of the limb.

This method will suffice in the majority of cases.

Reduction of Upward and Forward Dislocations.—In this form some form of traction must be made, as there is difficulty in flexing the thigh. The steps of the methods of Kocher and Bigelow are: 1. Traction in the axis of the limb as it lies. 2. Pressure with the hand upon the head of the femur to prevent its return upward during flexion. 3. Flexion. This should not be carried to a right angle. 4. The limb is now rotated inward. If the head lies nearer to the symphysis, abduction of the limb during traction is necessary.

Reduction of Upward (Supracotyloid) Dislocations.—Reduction is effected by moderate flexion followed by traction in the axis of the limb, with one hand at the knee and direct pressure downward and backward upon the head of the femur with the other hand.

Reduction of Downward (Infracotyloid) Dislocations.—Reduction in the cases collected by Wendel was effected by rotation, traction, and extension of the limb.

Allis' Method of Reduction of Dislocation of the Hip.—Dr. Oscar H. Allis, of Philadelphia, has made a most important contribution to the study of dislocations of the hip. He contends that there is but one obstacle to reductions of dislocations of the hip, and that lies in the capsule. He entirely ignores the long-accepted theory that muscular structures play any part either in the so-called button-holing the head of the femur or binding it by tendons, as in Bigelow's theory of the obturator internus, or in Sir Astley Cooper's theory of the head getting into the sciatic notch. He bases his theory on experimental work, and says that dislocations can be made on the cadaver that admit of no possible reduction. He claims that dislocations accomplished by flexion and abduction of the thigh are likely to tear the capsule at a distance from the acetabular border, and all this class are restored with difficulty, if at all, while dislocations produced during flexion, adduction, and rotation freely tear the capsule and these present no obstacles to reduction. He has shown that the secret of easy reduction lies in firm fixation of the pelvis. "The fixation is accomplished" by means of four large screw-eyes—two placed at the perineum and one on either side of the pelvis on a level with the crista ilii. A piece of hoop iron about six inches long, bent like the letter "C," serves a good purpose in keeping the fixation bandage from interfering with the manipulation. The bandage is passed across the abdomen, which prevents lateral motion, while the pubes is held by means of the bandage passing from the perineum to the iron plate.

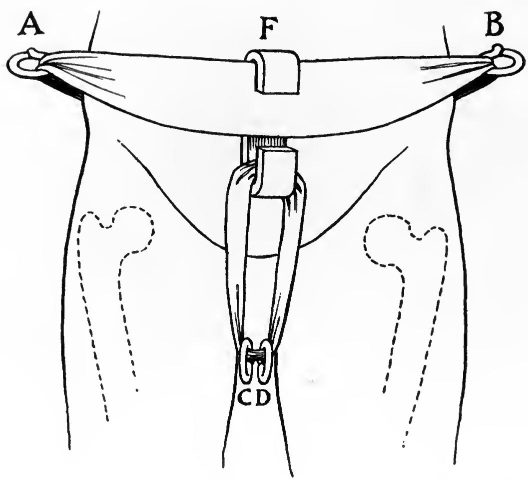

Fig. 307.—Method of Fixation of Pelvis for Reduction of Hip Dislocations, According to Allis.
A, B, C, and D, Four screw-eyes (see text on page 424); F, hoop iron band bent like letter C.

Treatment of Central Dislocations (p. 421).—Reduction is best effected by traction in an outward and downward direction in the axis of the femoral neck in order to pull the head out of the pelvis. No force should be employed during this manipulation. If the head has penetrated the pelvis too far, arthrotomy is indicated. The limb should be kept in a Buck's extension for six weeks.

After-treatment of Dislocations of the Hip.—No other treatment is required than rest in bed for three weeks, followed by massage and passive motion. The use of the limb is permitted after the third week. If the rim of the acetabulum has been broken off, it is necessary to apply a Buck's extension for four weeks.

Unreduced or Ancient Dislocations of the Hip.—If a traumatic dislocation of the hip is not reduced, pathologic changes occur which are quite similar to those observed in the shoulder (p. 381), and identical with those of a pathologic dislocation.

Cicatricial tissue forms in and around the fibrous tissue. This is hard to remove, and must be removed either with a curette or with a chisel. The most frequent obstacle to reduction is the capsule, which is often interposed between the head and the acetabulum. Another great obstacle is the condition of the muscles around the shaft. These are greatly shortened, so that even in an arthrotomy it is necessary to strip them from the neck and trochanter before reduction can be effected. In some cases normal cartilage has been found in the acetabulum, even though considerable time had elapsed since the injury. Fractures are often associated with traumatic dislocations and the detached fragments of bone become interposed between the head and acetabulum and prevent reduction.

A new acetabulum is formed by bony outgrowths around the head, which permits some motion of the limb. The principal disability is due to the faulty attitude of the limb and the necessity of tilting the pelvis in order to bring the foot to the ground.

The best method of treatment is by arthrotomy. Articles strongly advocating this method have been published by Drehman,[45] Payr,[46] Brüning,[47] and Goldmann.[48] Brüning was able in 1904 to collect 38 cases which had been operated upon. Of these, 33 were traumatic and 5 spontaneous dislocations. The majority were of the iliac variety, only 6 being obturator dislocations. The best incisions are those of Langenbeck or Kocher. The latter is a posterior one from the base of the trochanter to its tip, retracting the gluteus medius and minimus forward. In some cases it is necessary to dissect away the muscles from the neck and trochanter before the acetabulum can be exposed. The head is now freed, and after the acetabulum has been deepened, reduction is effected. The limb is kept extended with a Buck's extension for two weeks and then passive motion begun. The results have been most encouraging.

DISLOCATIONS OF THE KNEE-JOINT.

Although a dislocation between the femur and tibia is considered to be a rare form of injury, Cramer was able to collect 270 cases. They are divided, according to the direction in which the tibia is displaced, into forward, backward, inward, and outward forms, and, in addition, there is a fifth, or dislocation by rotation. The inward and outward forms are usually associated with more or less rotation.

Dislocation of the tibia forward is the most frequent form. One hundred and nine of the 270 cases collected by Cramer were of this variety, and 4 more cases have been reported by Brüning, Beinitz,[49] and Stori.[50] The most frequent cause is hyperextension of the thigh, usually by the trunk and thigh falling forward while the leg is fixed. It is generally complete, the lower end of the femur resting upon the posterior edge of the tibia. The popliteal vessels may be compressed to such an extent as to lead to gangrene of the foot, as in a case reported by Stori. The diagnosis is easy.

The tibia lies in a plane in front of that of the thigh. The outline of the tibia can be seen and felt lying in front of the lower end of the femur, the latter being prominent in the popliteal space. The limb may be fixed or movable in any direction. There may be evidences of injury of the popliteal artery and of the internal popliteal nerve, the former being recognized by the loss of pulsation and the latter by the loss of sensation.

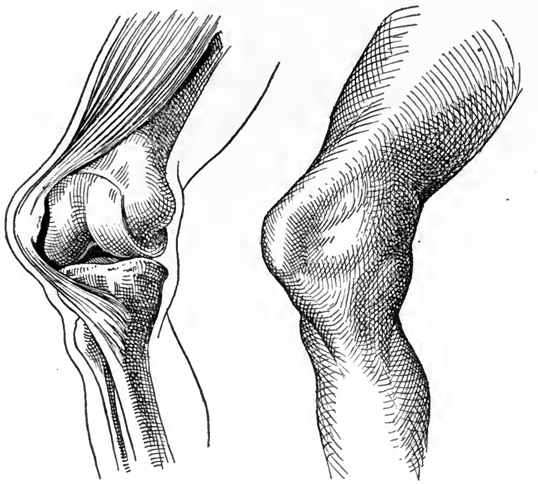

Fig. 308.—Outward Dislocation of the Patella (Hoffa).

In the backward variety the above signs are reversed. The head of the tibia lies behind the condyles of the femur and can be felt in the popliteal space. There is a marked depression below the condyles of the femur in front of the knee. Injury of the popliteal vessels is even more frequent than in the forward variety.

Lateral dislocations are quite rare, and their recognition is not difficult, the outer part of the head of the tibia projecting on the outer side of the joint in the outward and in the opposite manner in the inward variety.

Treatment.—Reduction in either of these dislocations is effected by traction on the leg while the thigh is flexed, combined with manipulation in order to guide the head of the tibia into its normal position. The limb should be placed upon a posterior splint for three weeks, after which passive motions are carefully begun.

Dislocations of the Patella.—About 200 cases of dislocation of this bone have been reported. Dislocation may occur outward, inward, or edgewise (vertical). Of these, the outward variety is the most frequent, and may result from muscular action or direct violence. The knee appears flatter and broader than usual, and the intercondyloid notch is quite prominent. The patella can be felt on the outer side of the condyle, and at its upper and lower ends respectively the quadriceps tendon and ligamentum patellæ can be felt as tense bands. The inward and vertical forms are rare, and their recognition is similar to that of the outward form. Reduction may occur spontaneously, but is usually effected by manipulation. The thigh is flexed on the abdomen and the knee extended, so as to relax the quadriceps, and then a little pressure on its outer margin causes the bone to slip back into place. In the incomplete form, where one of the borders of the bone is lodged in the intercondyloid notch, reduction is sometimes very difficult, and to effect it an open operation may be required.

The inward dislocation is rare, being always due to direct violence. In character and treatment it is the exact converse of those met with when the bone is displaced outward.

A dislocation edgewise, or vertical rotation of the patella, is when the bone is twisted vertically upon its own axis through 90 degrees so that its edge lies in the depression between the two condyles of the femur. If the joint surface faces outward, it is called a vertical outward form. If it faces inward, it is termed a vertical inward form. The position of the patella is readily recognized when the leg is extended.

A case of complete reversal of the patella has been reported by Pringle, who collected 7 other cases.

A horizontal dislocation is very rare. Kuttner[51] has given a review of all the cases published.

Habitual dislocation of the patella is usually to the outer side and complete. One of the best papers is that of Graser.[52] The most frequent cause is the condition of the lower end of the femur. Genu valgum seems to favor its occurrence. Other causes are injury to the vastus internus and chronic arthritis. The condition is easily recognized by the frequent recurrence of the dislocation. The best treatment is by arthrotomy. Various methods have been suggested to prevent recurrence. Some surgeons, like Le Dentu, have proposed narrowing the inner portion of the capsule. Other methods are—(*a*) Resection of a portion of the quadriceps tendon; (*b*) transposition of the tubercle of the tibia; (*c*) formation of a groove in the lower end of the femur; (*d*) insertion of an ivory peg into the external condyle (Trendelenburg); (*e*) osteotomy of the lower end of femur, followed by inward rotation of the leg (Graser).

Dislocation of the Upper End of the Fibula.—About 25 cases have been reported of this injury. It is often complicated by a fracture of the tibia or fibula. In the majority the displacement was outward and forward. Reduction is effected by direct pressure.

DISLOCATIONS AT THE ANKLE-JOINT (TIBIOTARSAL DISLOCATION).

These injuries are very rare, constituting, according to the statistics of Krönlein, about 0.5 per cent. of all dislocations. The dislocation may be complete or incomplete, the latter being the more frequent of the two. Both complete and incomplete dislocations of the ankle-joint are often associated with fractures of one or of both bones of the leg. Some writers believe that a dislocation does not occur without a fracture of the bones of the leg. Pels-Leusden,[53] who collected the cases which were observed at the Charité in Berlin, was unable to find a single case of dislocation of the ankle without an accompanying fracture of the bones of the leg. Others, like Ebel,[54] believe that a pure dislocation can occur without a fracture.

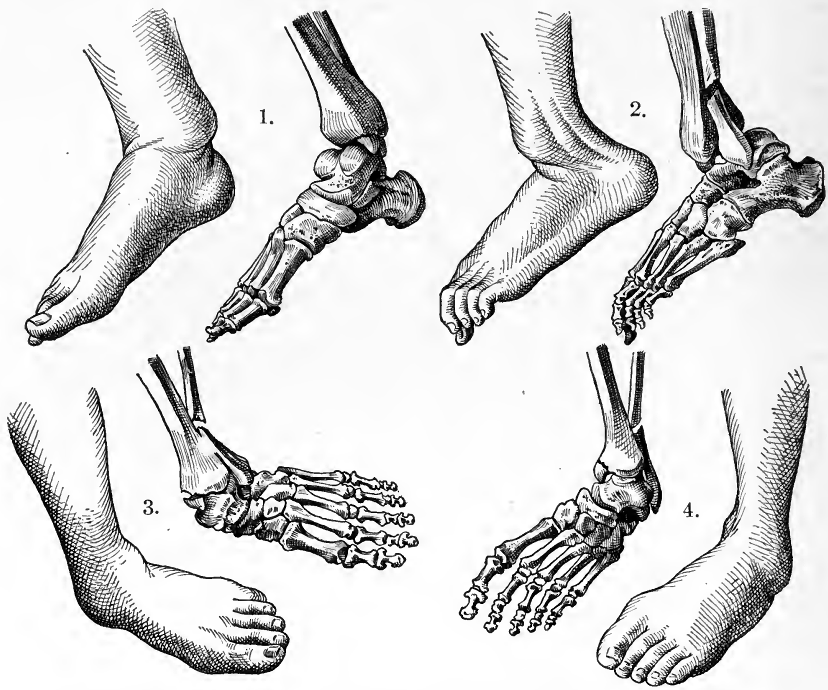

FIG. 309.—VARIOUS FORMS OF DISLOCATIONS OF THE ANKLE-JOINT (Hoffa).
1, Forward dislocation of the foot; 2, backward dislocation of the foot, associated with fracture of the fibula; 3, outward dislocation of the foot, associated with fracture of the tibia and fibula; 4, inward dislocation of the foot, associated with fracture of the tibia and fibula (see text).

The best division of dislocations of the ankle is into—(1) Those which occur in a sagittal direction, *i. e.*, forward or backward, and (2) those which occur in a lateral direction, *i. e.*, outward or inward.

1. **Dislocations in a Sagittal Direction.**—(*a*) **Backward Dislocations.**—These occur more frequently than those in a forward direction. The injury usually is the result of a fall backward while the foot is fixed. This causes an extreme plantar flexion of the foot. The astragalus, and with it the foot, are displaced backward. The lateral ligaments are usually extensively torn. In the majority of cases there is an accompanying fracture either of one or both malleoli or of the shaft of the fibula.

Diagnosis.—The front portion of the foot is shortened (Fig. 309), while the heel is more prominent than normal. The lower end of the tibia protrudes over the dorsum of the foot, and the sharp edge of its articular surface is to be felt distinctly. The extensor tendons and the tendo Achillis are tense and prominent. It may be distinguished from a supramalleolar fracture by the fact that the malleoli in the latter have moved backward with the foot, while in a dislocation backward they are prominent at some distance in front of the heel.

Treatment.—Reduction is usually effected by forced plantar flexion, the foot being pulled forward and the lower end of the tibia pushed backward. These steps are then followed by dorsal flexion of the foot. After reduction the leg should be immobilized for three weeks in a molded posterior splint. Light passive motion can be begun during the fourth. In old unreduced cases an arthrotomy in indicated.

(*b*) **Forward Dislocations.**—These are much rarer than the backward form. They are usually due to a forced dorsal flexion of the foot. This form is less often accompanied by a fracture of the malleoli than is the case in the backward dislocation. The fibula is seldom broken, the usual seat of fracture being in the tip of the internal malleolus or in the articular surface of the tibia. Like the backward form, the dislocation may be complete or incomplete. The injury is often a compound one.

Diagnosis.—The whole foot appears to be lengthened. The prominence due to the heel has disappeared. The upper articular surface of the astragalus can be felt, the tibia and the malleoli being nearer to the heel. It can be differentiated from a fracture of both bones of the leg above the malleoli by the fact that in a forward dislocation the malleoli are further back than normal, while in a supramalleolar fracture they have moved forward with the foot.

Treatment.—Reduction is readily effected by marked dorsal flexion of the foot, pressure being made in a forward direction upon the lower end of the tibia, and the foot pushed backward. Plantar flexion now completes the reduction. The after-treatment is the same as in the backward form.

2. **Dislocations in a Lateral Direction.**—A lateral dislocation of the ankle-joint cannot occur without a fracture of one or both malleoli. This is due to the fact that the astragalus is held in a vise-like grip by the lower ends of the tibia and fibula. The manner in which they are produced and the pathology are quite similar to that of the fractures of the lower end of the tibia and fibula described on p. 265. The chief difference is that the forced adduction or abduction (inversion or eversion) of the foot is carried further in a lateral dislocation.

(a) **Dislocation Outward of the Foot.**—This is the more frequent of the two forms of lateral dislocation. It is the result of a forcible abduction of the foot, which produces a fracture of the fibula and a laceration of the internal lateral ligament, or the internal malleolus is broken. The astragalus is rotated so that its upper convex surface is directed toward the internal malleolus (Fig. 309). In some cases a rotation of the astragalus and foot occurs, so that the toes point outward. The name outward rotation-dislocation of the ankle has been given to this form. Schubert[55] has recently reported two such cases associated with a high-seated spiral fracture of the fibula. The diagnosis of the ordinary outward dislocation does not differ from that of an abduction fracture. The foot is markedly abducted—much more so than in an ordinary Pott's fracture. The inner border of the foot points upward, while the outer rests upon the ground or table (Fig. 309). The upper articular surface of the astragalus is to be felt just below the internal malleolus, and projects beneath the skin or even protrudes through it. There are, in addition, the ordinary signs of fracture of the tibia and fibula.

The *diagnosis* of a rotation-dislocation can be made from the position of the foot. The foot is rotated outward so that it forms a right angle with the axis of the leg. The toes point directly outward. The *x*-ray is of the greatest possible aid in the diagnosis of all these injuries in the vicinity of the ankle.

(b) **Dislocation Inward of the Foot.**—In the majority of cases an inward dislocation of the foot is in reality a fracture of the malleoli by forcible adduction of the foot. Quite rarely, however, the movement of adduction may be carried so far as to produce a true inward dislocation of the foot. Wendel,[56] who collected 108 cases of true dislocations of the ankle, was able to find three such cases. They invariably followed such injuries as a fall with the foot caught beneath the body or a forcible adduction of the leg while the foot was fixed.

The *diagnosis* is usually easy. The upper convex surface of the astragalus is directed toward the external malleolus and can be felt here. The inner border of the foot is raised; the outer rests upon the table or bed. This form of dislocation is very frequently a compound one, or it is accompanied by fractures of the bones of the leg or of the astragalus, but it may occur without these injuries.

The **treatment** of these lateral dislocations differs but little from that of fractures of the lower end of the tibia and fibula (p. 266). Reduction is effected by adduction or abduction of the foot, but the chief danger is from infection, on account of the extensive injury of the skin and soft parts.

If reduction is impossible, it is best to perform an arthrotomy.

SUBASTRAGALOID DISLOCATIONS.

Two forms of dislocation can occur in the joint between the astragalus and the two tarsal bones (os calcis and scaphoid), with which it articulates.

In the true subastragaloid form the astragalus continues to articulate with the tibia and fibula, but it is displaced from its articulation with the os calcis and the scaphoid. In the second form of subastragaloid dislocation the astragalus is completely separated from its articulation with the bones of the leg, as well as with the calcaneus and scaphoid. To this form the name *total dislocation of the astragalus* is given.

True Subastragaloid Dislocations (Luxatio pedis sub talo).—This dislocation may occur in four directions, viz., inward, outward, forward, and backward. Including the cases collected by Dietz[57] and Trendel[58] and those recently reported by Wendel[59] and Thienhaus,[60] 84 cases have been observed. Of these, 50 have been of the inward and 21 of the outward variety. There were 6 cases of the anterior and 7 of the posterior variety. In a few cases there have been accompanying fractures of the astragalus.

(a) **Dislocation Inward.**—The most frequent cause is a forcible adduction of the foot combined with violence acting in the direction of the long axis of the foot. As examples may be mentioned a fall upon the heel while the foot is in a position of extreme adduction or a blow upon the inner side of the foot.

The diagnosis can be made from the position of the foot. The foot is adducted and rotated inward, as in a case of club-foot. The sole of the foot is directed inward. The inner edge of the foot is concave and shortened, while the outer edge appears lengthened. The external malleolus and head of the astragalus are very prominent on the outer side of the foot. Below and behind the inner malleolus the scaphoid projects beneath the skin.

(b) **Dislocation Outward.**—This occurs after forced abduction of the foot. The symptoms are the opposite of those of the inward variety. The foot is in the position of a flat-foot, its inner edge depressed and outer edge raised. The inner malleolus is close to the sole of the foot, and in front of it the head of the astragalus forms a prominence. The injury is not infrequently compound, so that the astragalus presents in the wound.

(c) **Dislocation Backward.**—The cause is usually a forced plantar flexion of the foot. The signs are very pronounced; the head of the astragalus can be seen and felt lying upon the upper surface of the scaphoid and cuneiform bones. The anterior portion of the foot is shortened, while the heel is lengthened and the tendo Achillis is very prominent.

(d) **Dislocation Forward.**—This follows forced dorsal flexion of the foot, the patient falling forward after landing with his heels upon the ground. The diagnosis can be readily made, unless the swelling be too great, from the lengthened anterior portion of the foot and the shortened heel.

An important point in the diagnosis of subastragaloid dislocation is the absence of any prominence due to the projection of the body of the astragalus in front, behind, or to either side of the malleoli, as is the case in the tibiotarsal dislocations described above. A second fact is the abnormal position of the calcaneus and scaphoid with relation to the malleoli and astragalus. The swelling is usually so great that a diagnosis is very difficult without the use of the *x*-ray.

Treatment of Subastragaloid Dislocations.—Reduction can usually be effected in recent cases by manipulation and traction. In the inward variety the existing adduction is at first increased. Pressure is now made over the outer side of the astragalus and the inner side of the foot, and the foot then strongly abducted. In the outward variety the abduction is first increased. Pressure is then made over the outer side of the foot until reduction is effected. In the backward variety the plantar flexion is first increased and the foot then strongly flexed in the opposite direction. In the forward variety forced dorsal flexion will effect reduction. The foot should be placed upon a posterior molded splint for three weeks, after which passive motions are begun.

If reduction is impossible, an arthrotomy with excision of the astragalus may be necessary. It does not interfere with good functional use of the foot.

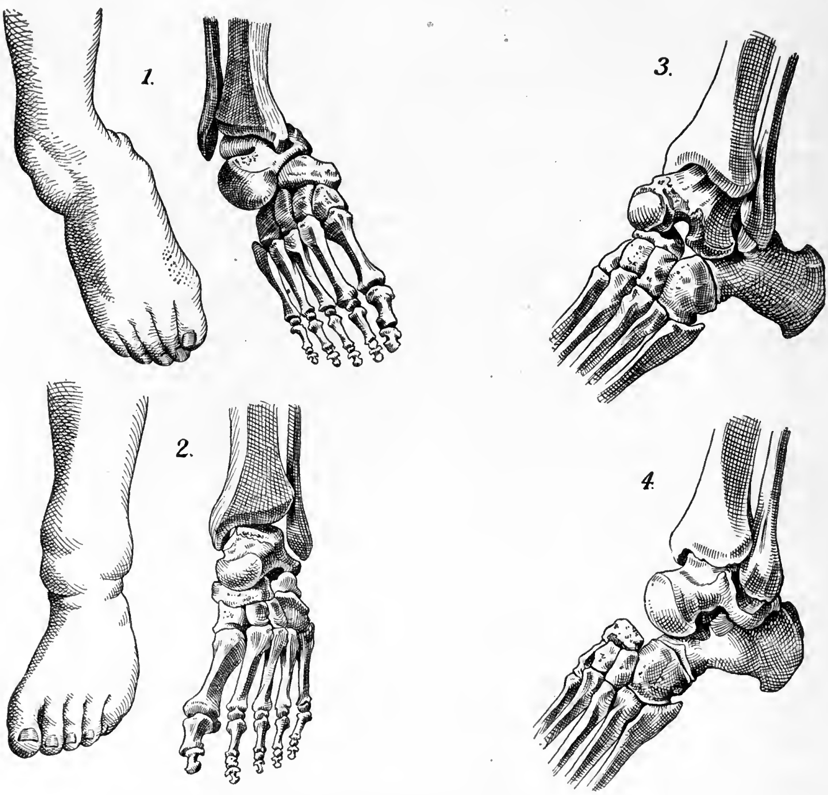

FIG. 310.—VARIOUS FORMS OF SUBASTRAGALOID DISLOCATION OF THE FOOT (Hoffa). 1, Outward; 2, inward; 3, backward; 4, forward.

Total Dislocation of the Astragalus.—This form of dislocation is much more frequent than those of the ankle-joint proper or of the articulation between the astragalus, calcaneus, and scaphoid.

The displacement of the astragalus may occur in one of six directions: (*a*) Forward; (*b*) outward and forward; (*c*) inward and forward; (*d*) inward; (*e*) backward; and (*f*) by rotation. The most frequent variety is the outward and forward. In this variety the foot is rotated markedly inward and the external malleolus is very prominent. The foot is in a club-foot position. The dislocated astragalus can be felt as an irregular angular bone just below the external malleolus.

Attempts at reduction have succeeded in many cases by traction upon the foot and direct pressure over the displaced bone. If this is unsuccessful, arthrotomy is indicated. The astragalus can be removed without interfering with the usefulness of the foot.

Dislocations of the Metatarsal Bones.—These may be either complete or incomplete at Lisfranc's joint. It occurs most often in an upward direction. They may follow such injuries as being run over or the fall of a heavy weight upon the foot or forcible flexion of the foot. The dorsum of the foot is more convex than normal, while the sole of the foot is flattened. One can see and feel the displaced upper ends of the metatarsals on the dorsum of the foot. The foot is shortened and the toes point inward. Dislocations of the individual metatarsal bones are much rarer. The middle ones are displaced upward, and the first and fifth inward and outward respectively.

Dislocations of the Toes.—These occur most often in the metatarsophalangeal joint of the great toe after forcible dorsal flexion. The dislocation may be complete or incomplete. In the former case the proximal end of the first phalanx is prominent on the dorsum of the foot, and on the sole of the foot the head of the metatarsal bone projects. Their reduction presents no difficulties.

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CHAPTER XXVII.

SURGERY OF THE MUSCLES, TENDONS, AND BURSÆ.

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THE MUSCLES.

Degenerations.—Muscles are subject to various degenerations, such as fatty and amyloid degeneration, and coagulative or Zenker's necrosis. The cause of degeneration is usually intoxication from diseases like typhoid, tuberculosis, and sepsis, or from poisoning by chemical agents, *e. g.*, alcohol, lead, etc.

Atrophy.—Muscular atrophy may be simple or combined with some form of degeneration (fatty, amyloid, etc.). The simplest form of atrophy is that due to inactivity. When a limb is kept at rest, the muscles become lessened in size and flabby; the individual fibers become thin—some even disappear; there is no great change in the electrotonus, no reaction of degeneration. The same atrophy is well seen when muscles are subjected to pressure and stretching, *e. g.*, the abdominal muscles in extensive ascites. Pressure and inactivity both cause malnutrition. Paget, Hoffa, and others believe that the atrophy accompanying articular disease is not due merely to inactivity, but that the primary disease sends impressions to the ganglion-cells in the anterior horn of the cord, where changes are produced which interfere with their trophic function, and thus the atrophy is reflex. Strasser and others have pointed out that even in this form of atrophy the muscles affected are those only whose function belongs exclusively to the joint diseased, *e. g.*, when the knee-joint is diseased, the vasti become atrophied, while the rectus, whose function belongs both to the knee and hip, remains intact.

After myositis, atrophy may develop, repair from the inflammation resulting in the formation of fibrous tissue which to a greater or less extent replaces muscular fibers. When the nerve supplying a muscle or group of muscles is divided or its conducting power is destroyed by pressure, distention, or inflammation (neuritis), there is simple atrophy plus degeneration. If the musculospiral nerve is seriously injured in fracture of the humerus, there is immediate paralysis of the extensor muscles of the forearm. The "reaction of degeneration" soon appears, *i. e.*, the muscles no longer respond to the faradic current, but exhibit increased sensibility to the galvanic, the anode closure contraction being greater than the cathode. Section of or injury to the nerve has cut off the normal trophic influences and consequently atrophy plus degeneration becomes evident. The muscle-fibers diminish in size and number, but they may also undergo fatty, amyloid, or coagulative degeneration and disappear, their place to a greater or less extent being taken by fibrous tissue, which is usually infiltrated with fat. The destruction of the muscle is often only partial, and then recovery ensues under proper treatment.

Atrophy of a similar character results from neuropathies, *e. g.*, anterior poliomyelitis, which interfere with the conductivity of the nerves. Atrophic muscles, unless sclerosed, are with few exceptions small, soft, and flabby, pale or white or yellow in hue. In a few cases the muscle-fibers are replaced by connective tissue or fat in such quantity that the bulk of the muscle is apparently much increased, although in reality muscular tissue may be practically absent. The tumor of the thigh shown in Fig. 311 resulted from an injury to the adductor group of muscles. The tumor mass, removed three years later by J. W. Perkins, consisted of fat which had taken the place of the normal tissue elements.

FIG. 311.—LARGE FATTY TUMOR OF THIGH (Perkins). Boy aged fourteen. Injury from riding horseback three years previous to time patient was seen, since which the tumor has grown very fast. Had nodule there which slowly enlarged from childhood.

When a muscle becomes greatly sclerosed, it loses its functional power and becomes a contracted cord; thus deformity results. One of the best examples of this is seen in torticollis. Atrophied muscles are not commonly sclerosed: they are usually soft and flabby. When a muscle is thus affected, the opposing muscles remaining sound, deformity results, *e. g.*, during inflammation of the knee-joint atrophy is much more marked in the quadriceps than in the ham-strings, consequently the knee becomes flexed. When, following anterior poliomyelitis, there is paralysis of the tibialis anticus and extensors of the foot, the posterior healthy muscles contract, the paralyzed muscles elongate, and paralytic club-foot results.

Ischemic atrophy or Volkmann's contracture is a rather peculiar and important condition. The cause is interference with the circulation. Pressure on the nerves may have some influence. The circulation may be interfered with by the too tight application of splints and dressings, by the unduly prolonged use of the elastic constrictor (tourniquet), by injury to large vessels, and by prolonged exposure of the part to cold.

The forearm is the region most commonly involved. The affected muscles become densely infiltrated. Unless the cause is removed within twenty-four or forty-eight hours or earlier, the muscle-fibers degenerate. The whole muscle (Friedrich) does not become uniformly degenerated, but the portions attacked undergo contraction.

According to Dudgeon,[1] pain is absent unless the disease is accompanied by neuritis; other authors describe pain as an early and important symptom. Within a few hours the hand becomes swollen, the phalanges flexed, and there is paralysis of the muscles. The muscles are hard, swollen, and tender. If pain is absent, the seriousness of the condition is apt to be unrecognized. If splints are the exciting cause of the trouble, their pressure may occasion necrosis and ulceration of the skin, but these lesions are merely concomitants unrelated to the muscular degeneration. When recovery takes place, it leaves a permanent contracture. When the forearm is the site of the disease, the resulting deformity is characteristic. The phalanges are flexed on each other, but the metacarpophalangeal articulation remains extended. The phalanges cannot be extended while the wrist is extended, but as soon as the wrist is flexed, the fingers can be straightened. If the muscular destruction has been more extensive, the wrist becomes flexed as well as the fingers.

Treatment.—The principles on which muscular atrophy must be treated are: (*a*) Removal of the cause. (*b*) Provision of proper and sufficient nutriment. (*c*) Exercise. (*d*) Prevention of deformity.

(*a*) *Removal of the Cause of Atrophy.*—The methods of removing the cause of muscular atrophy belong, for the most part, either to works on internal medicine or to the chapters on the surgery of the nerves and of the bones.

(*b*) *Provision of Proper and Sufficient Nutriment.*—Primarily we must avoid any obstruction to the circulation. Tight bandages and constricting apparatus must be discarded or so applied as to do the least possible damage. The nutrition of the part must be stimulated by massage, electricity, and proper exercise.

(*c*) *Exercise* is the best means of avoiding and of treating atrophy. When possible, active exercise is ideal—nothing can equal it. Even when, owing to circumstances, it is unwise for a patient completely to contract the muscles, partial contraction frequently repeated is of enormous value. When the muscle is capable of responding to the faradic current, this ought to be employed to give exercise. When the reaction of degeneration is present, the galvanic current is indicated until recovery advances to such a point that the faradic becomes effective.

(*d*) *Prevention of Deformity.*—The methods of treatment already described are all efficacious in the prevention of deformity, but there are means specially appropriate for this purpose which must be considered. The means *par excellence* consists in keeping the articulation governed by the muscles at fault, in such a position that the atrophied muscles are relieved from all tension while the healthy ones are prevented from contracting. As a rule, it will be found that it is the extensors which have lost power, and hence the usual posture required is one of hyperextension.

Operative Treatment.—Drehmann, in a boy aged seven, exposed the sclerosed muscles, divided them transversely, thus permitting extension of the fingers. Finding the flexor profundus digitorum comparatively healthy, he sutured it to the peripheral stump of the divided muscle. In six weeks voluntary flexion and extension of the fingers were possible.

Myositis.—Inflammation of muscles may be simple or infective.

Simple Myositis.—As a result of trauma or some non-infective irritant the connective tissue of the muscle becomes embryonic and the cellular elements proliferate (the muscle-cells take part in this growth, though to a slight extent); thus granulation tissue is formed. Tissues irreparably injured are absorbed. If the local irritation is not continued, the granulation tissue becomes mature and recovery is complete. The process is entirely one of repair. If considerable tissue has been destroyed, there will be much substitution of scar tissue for muscular tissue and consequent loss of function.

Infective Myositis.—A muscle may become infected: (*a*) Directly through a wound or from neighboring foci of disease. (*b*) Indirectly, by metastasis.

The infective agents are of the usual varieties. When the inflamed muscle lies near the large intestine, saprophytic contamination is frequent and gangrene may result. This condition may be seen in some cases of inflammation of the psoas muscle, especially if the psoitis is due to extension of disease from an inflamed vermiform appendix. Muscle is more resistant to pyogenic infection than are most other tissues. It is not uncommon to find a muscle in an abscess cavity, and yet not involved in the inflammatory process.

There are several forms of infective myositis which require special mention:

(*a*) **Primary Infectious Myositis.**—This disease is analogous to osteomyelitis, and is characterized by the formation of abscesses in one or more muscles. It appears in adults whose vitality has been impaired by want or exposure. The muscles most vulnerable are those which are most used, viz., the pectorals, the triceps, the adductors of the thigh, etc.

The affected muscle becomes hard and swollen, of a greenish or grayish color. The focus of inflammation breaks down into a thin, sanious, or a creamy pus. The pus may be contained in a ragged cavity or may infiltrate the whole muscle. The muscular fibers undergo fatty degeneration.

The lymphatic glands belonging to the affected region become enlarged. Primary myositis may manifest its presence suddenly by a sharp pain after some effort. Usually the symptoms begin with a feeling of malaise and chilliness. The temperature rises, the pulse becomes rapid, and there is much prostration. In very acute cases death may supervene before any local symptoms manifest themselves. As a rule, the patients complain of diffuse pains, but these soon become localized in one or several places where there are tenderness and a hard induration. Fluctuation appears only after the suppuration has spread into the surrounding tissues.

Death is common before the abscesses are evacuated. As a rarity, resolution may take place; in these cases the systemic poisoning is slight. The treatment must be supportive. Locally, early incision and drainage give the best prospect of relief.

(*b*) **Acute Polymyositis (Pseudo-trichiniasis or Dermatomyositis).**—The origin and pathologic anatomy of acute polymyositis are similar to those of the preceding disease, but its course is very different.

For days and even weeks lassitude and vague muscular pains are noticed. There is no fever. The pains gradually increase in severity, become located in a number of muscles, and over the painful areas edema appears. The muscles affected become contracted. Cutaneous eruptions are common, are often macular, but may resemble erysipelas. The physical signs make one suspect the presence of pus, but on incision none is found, and if kept clean, the wound heals promptly. In subacute or chronic cases the temperature remains normal and the patient's general condition is good. Recovery is very slow and atrophy is common. In severe cases there is a moderate amount of fever with increase in the pulse-rate, weakness becomes profound, and the patient dies from broncho-pneumonia.[2]

(*c*) **Myositis Ossificans.**—Myositis ossificans progressiva is a rare disease, beginning in early life. The muscles, especially those of the back, become infiltrated with bony material until the patient is in a helpless condition. The cause is entirely unknown and treatment is futile.

Myositis Ossificans Traumatica.—As a result of frequently repeated trauma it is not uncommon to have a formation of bone in the belly of a muscle. Familiar examples of this are "drill bones" in the insertion of the deltoid, "rider's bone" in the origin of the adductors of the thigh.

Bone occasionally develops in a muscle after a single trauma. Sometimes this is due to simultaneous injury inflicted on the muscle and the periosteum, bone-forming cells escaping into the contused muscle and developing there; at other times a muscle contracting vigorously may tear a portion of periosteum from the bone and pull such into its substance, where development takes place. All the above forms are essentially exostoses, but under the influence of trauma it is undoubtedly true that the muscular connective tissue can become metamorphosed into bone. Probably this metamorphosis took place in the brachialis anticus of the arm, shown in Fig. 312.

The osseous neoplasm developed in eight weeks and caused much disability; about nine months after its removal by R. M. Schauffler the patient was playing base-ball.

The diagnosis of myositis ossificans traumatica does not require any discussion; the treatment consists in excision unless the new-growth is neither increasing in size nor causing annoyance.

Tuberculosis of Muscles.—Muscles may become infected either by direct extension from neighboring foci of tuberculosis or by metastasis.

1. *Infection by Direct Extension.*—This is the commonest mode of infection. The lesions are usually nodular. The nodules may coalesce, caseate, and break down into tuberculous pus. If the resisting power of

the tissues is sufficient, sclerosis and muscular atrophy may result instead of abscess. Examples of this method of infection are seen in tuberculous psoitis from the bathing of the muscle in pus from vertebral disease; in tuberculosis of the quadriceps femoris from gonitis; in disease of the sphincter from tuberculous ulceration at the anus.

2. *Metastatic Infection. Primary Tuberculosis of Muscle.*—Lanz and de Quervain[3] have made a very careful study of this very rare disease. Usually the local lesion is secondary to disease in a bronchial gland.

FIG. 312.—MYOSITIS OSSIFICANS TRAUMATICA (Schauffler).
The tumor in brachialis anticus developed to extent shown in eight weeks after patient received severe blow on muscle while it was tense.

Trauma is of importance by establishing a *locus minoris resistentiæ.* The virus acts particularly on the muscular connective tissue. The muscular fibers of the involved area atrophy. The disease may be miliary, or one or more solitary nodules may form. As the disease progresses the originally discrete nodules may increase in size, coalesce, caseate, and form an abscess. The abscess may break through the fascia and form an encapsulated or a wide-spread cold abscess.

Symptoms.—The symptoms are often very obscure. Pain and tenderness are usually slight. Impairment of function is only noticed after the disease has become fairly extensive. Fever is absent in the early stages. A palpable nodule is usually movable in a relaxed, but immovable in a contracted, muscle. The history of the case, slow growth, absence of marked pain or disability, presence of tuberculous lesions elsewhere, absence of history or stigmata of syphilis, etc., must be relied upon for diagnosis.

Treatment.—As soon as the diagnosis is made, operation is indicated. When the disease affects a limited portion of one muscle, the lesion ought to be dissected out *en masse*, or if the muscle involved is small and unimportant, *e. g.*, the palmaris longus, it should be removed with the disease. When a muscle is extensively involved, the whole of it should be excised, and if it is one of functional importance, its tendon should be united to some neighboring muscle of similar function. Incomplete operations often lead to greater disability than do complete ones. When muscular tuberculosis is merely an extension of osseous, articular, or glandular disease, the same principles of treatment hold good, viz., complete removal of the tissues involved. After abscess has formed, the ideal treatment is complete removal of the intact abscess in the same manner as a tumor would be removed. Generally this is impossible or improper. If the abscess cavity is extensive and unopened, it is proper to evacuate the contents and inject into it an emulsion of iodoform in glycerin (5 to 10 per cent.). The evacuation and injection may require to be repeated. When neither complete extirpation nor injection is suitable, the abscess must be incised, its contents evacuated, and its walls either excised or curetted. After curettement it is advantageous to swab the cavity with liquid carbolic acid, followed by alcohol to neutralize it. Tubular or gauze drainage must be provided. The results obtained after the excision of tuberculous nodules in muscles have been excellent.

Syphilitic Affections of Muscle.—Besides the muscular pains often observed very early in the course of syphilis, a more serious and poorly understood condition may arise about the end of the first year after infection. Certain muscles, particularly the biceps, slowly contract until the elbow may be flexed to an acute angle. Motion, whether active or passive, causes pain. Electric irritability is lowered. Nothing is known as to the pathologic anatomy of the disease; untreated, the contractures may persist for years; under specific medication they rapidly disappear.

During the tertiary period of syphilis the muscles may be affected more seriously. Fortunately, the diseases about to be described are rare.

A. *Diffuse Syphilitic Myositis.*—The connective-tissue cells of the muscle proliferate and form a hard infiltration, causing muscular atrophy. If left untreated, the atrophy progresses and sclerosis results. Under specific medication during the stage of infiltration recovery is prompt. The evidences of the disease are: swelling and hardening of the muscles involved; greater or less impairment of function; pain on motion; night pains These, combined with the history, suffice for diagnosis. The muscles most commonly involved are those of mastication, of the calf, and the sternomastoids.

Gummata of Muscle.—Gummata in muscles present the same anatomic features as they do elsewhere. They may be hard or soft, according to the preponderance of cells or of fluid in them. The muscles usually involved are those of the tongue, the external sphincter ani, or the sterno-mastoid. A muscular gumma may be of slow growth, painless, or of rapid growth, and if located near nerves, very painful. Those of the sphincter are especially painful. The lesions may be single or multiple, and involve one or several muscles. The disease has been noted soon after birth. While the gumma is growing, the muscle in which it lies is generally in a state of contraction. The results of muscular gummata are resolution or advance of the process, with fatty or coagulation necrosis. The degenerated material becomes absorbed, and its place is taken by scar tissue which, according to the amount of destruction, occasions deformity. Often the gumma spreads, involving neighboring structures, even the skin, so that a deep sloughing ulcer results, which, when it heals, leaves the muscle, fascia, and skin fused together in a rigid scar.

When a gumma of the muscle is single, it is usually mistaken for a sarcoma. The diagnosis must be based on the history and on therapeutic tests. The treatment consists in specific medication. Complications, such as ulceration and contractions, must be attended to on the usual surgical principles.

Actinomycosis of Muscle.—The actinomyces (ray fungus) may gain access to a muscle either directly or by metastasis. The latter method is rare. In most regions there is no distinction between the effects of the disease on muscle and on other neighboring structures. The tissues become the site of a very hard infiltration and of deposits of granulation tissue containing masses of the fungus. In the pyemic type of actinomycosis the muscles are rarely involved. DeQuervain[4] notes that actinomycosis when it attacks the tongue, no matter what the mode of infection, acts differently from what it does in other tissues or organs. A few weeks after infection a hard nodule, rarely larger than a hazel-nut, appears in the anterior half of the tongue. Instead of invading the surrounding muscle, it remains isolated. In time the center of the mass softens, but ulceration is rare. Actinomycosis does not tend to invade the lymphatics.

The diagnosis is generally easy when ulceration is present or an incision has been made. In the discharge and in the tissues we find the small, gritty yellow or whitish pearls of ray-fungus. Under other circumstances the diagnosis from gumma, sarcoma, tuberculosis, etc., is almost impossible. A "therapeutic diagnosis" between actinomycosis and syphilis is impossible because in both diseases the iodids act beneficially.

Treatment.—Except in lesions of the tongue, treatment is the same as in actinomycosis of other structures. (See Vol. I, p. 524.) When the tongue is affected, excision of the growth is the only proper treatment.

Hydatid Cysts.—Thomas (quoted by C. Lyot[2]) found muscles the site of hydatid cysts in 1.90 per cent. of cases. The echinococcus embryos having been carried into a muscle by the blood, develop and form a cyst which pushes the muscle-fibers apart and forms for itself a fibrous capsule at the expense of the perimysium. The cyst grows very slowly, and rarely becomes larger than a hen's egg. The irritation of its presence may produce sclerosis. If the cyst contents die, it may shrivel into a caseous or calcareous mass. If infection gains access, inflammation develops. Hydatid tumors are hard and elastic; fluctuation is not common; in about one-half of the cases the "hydatid thrill" may be elicited. There are usually a leukocytosis (17,000–19,000) and a marked eosinophilia, even up to 57 per cent. In very chronic cases the eosinophilia may be absent. Exploratory puncture is very proper, as only by examination of the cyst contents is an absolute diagnosis possible. In its growth the cyst may press upon neighboring structures, eroding them, and thus may invade various cavities, such as the thorax and abdomen.

Treatment.—1. By injection. With a medium-sized cannula evacuate the cyst contents and inject a few drams of a solution of corrosive sublimate (1: 1000). This method of treatment often fails, but it may be tried on patients who refuse more radical measures.

2. By operation. A. Excision. Expose the cyst by a free incision and remove it entire. B. Incision. Incise the cyst freely. Remove its gelatinous walls by means of a curette and of gauze swabs. Provide for drainage.

Trichiniasis.—Trichiniasis is distinctly a muscular affection. The embryos of the trichina spiralis enter the muscles through the blood. The flat muscles are those principally involved. When the embryo is lodged in a muscle, it becomes coiled up and lies inside a fibrous capsule. Soon the capsule becomes calcified, the parasite dies, and only a minute hard nodule remains. A few of the parasites may exist in a muscle without causing any symptoms, but when they are present in great numbers, they occasion great pain and may cause death, usually from pneumonia. The symptoms are fever, muscular pain, stiffness, and swelling. There are loss of appetite, prostration, edema of the face and extremities. Da Costa[5] saw a case mistaken for erysipelas because of the high fever, the delirium, and the edematous redness of the neck and face. In 1897 T. R. Brown, of Baltimore, first showed that there is a marked leukocytosis with an absolute and relative gain in the eosinophilia in cases of acute trichiniasis. It is occasionally absent. In obscure cases it may be the only indication leading us to suspect trichiniasis.

A positive diagnosis can be made only by the examination of excised portions of the affected muscles.

Treatment.—With purgatives, clean out the intestinal canal to prevent further infection. As the disease is self-limited, usually lasting from two to several weeks, during this period the strength must be kept up by suitable diet and symptoms treated as they arise.

Tumors of Muscle.—Carcinomata only appear in muscles as secondary growths. Sarcomata, *e. g.*, of the sternocleidomastoid, are by far the most common tumors in the voluntary muscles. They arise from the intramuscular connective tissue, and may be of any of the usual varieties, round-cell, spindle-cell, etc. Adult connective-tissue tumors are rare. The fibromata occurring in the rectus abdominis, though uncommon, are well known and require special mention. Pfeiffer[6] found that 89.4 per cent. of these tumors occurred in women, and that almost all these women had borne children. He believes that the normal proliferation of the tissues of the abdominal wall which is found during pregnancy is, in these cases, kept up in limited areas, and thus the tumors arise. These fibromata of the abdominal wall are named "desmoids." Angeiomata are among the less uncommon tumors of muscle except in the sternomastoid, where they are fairly frequent.

When a tumor is situated in a muscle, it is movable while the muscle is relaxed, but as soon as the muscle is contracted, the tumor becomes fixed. Tumors near a muscle and secondarily adherent to it show the same peculiarity. In diagnosis, careful attention to the history of the case and observation of the general condition of the patient are of great importance, but even then it is often impossible to reach a definite conclusion, as the physical appearances of sarcomata, fibromata, syphilomata, etc., are so much alike.

Treatment.—On general principles all tumors ought to be excised. If a malignant tumor is apparently confined within the limits of a single muscle, the excision of that muscle, from origin to insertion, may be sufficient; in all other cases amputation is the operation of choice where an extremity is involved. The principles of treatment are the same as those for tumors in general.

Injuries to Muscles.—A. **Subcutaneous Injuries Due to Direct Violence.**—Blows, kicks, or falls are the commonest causes of subcutaneous injuries or contusions, but they may also result from traumata inflicted by the bones in fractures or dislocations. Muscles are most easily contused when in a rigid condition.

Injuries vary much in severity: (*a*) In slight cases only a few muscle-fibers are injured. There is a trifling effusion of blood. Skin discoloration due to intramuscular hemorrhage appears late, and is possible only when the fascia has also been injured. Complete recovery ensues in from one to three weeks. The symptoms and treatment of slight contusions are identical with those of rupture.

(*b*) In more severe cases there is much more destruction of muscular tissue—in fact, the muscle may be completely divided. The effusion of blood is proportionately greater, a true hematoma resulting. Fortunately, infection rarely supervenes, and recovery, with or without disability, is the rule. In the most favorable cases the whole of the blood and destroyed tissue are absorbed, and practically complete *restitutio ad integrum* obtained.

It is more common to find that as the blood is removed connective tissue is deposited and a mass of scar tissue—a callus—is left like a tumor in the muscle. According to the size and situation of the callus, and particularly to the presence or absence of adhesions between it and the surrounding structures, disability will be present or absent. Instead of being absorbed, the blood may become encapsulated, forming a cyst, the contents of which are at first blood but later serum. If the injury is near the origin or insertion of a muscle, bone may be deposited in it during the process of repair. (See Myositis Ossificans.)

B. **Open Injuries to Muscles Due to Direct Violence.**—In this class of injuries the skin is divided and the possibility of infection is always present. The symptoms and principles of treatment are the same as for any open wound. If a muscle is partially or completely divided, we must, if possible, secure union of the divided ends by means of sutures. If so much of the muscle is destroyed that its function is lost, we may join its tendon to a neighboring muscle, preferably one of similar action.

C. **Rupture.**—A muscle may become partially or completely ruptured by its sudden and severe contraction. Atrophy and degeneration are common predisposing causes. Very slight degrees of rupture, involving only a few muscular fibers, are common. When this accident occurs to the lumbar muscles, it simulates lumbago. "Lawn-tennis" leg is a well-known example where a few fibers in the calf are torn (it is usually supposed that the plantaris is ruptured in this lesion; it is more probable, however, that some fibers of the gastrocnemius are involved, either alone or with the plantaris). After a sudden twisting motion the patient experiences a pain in the calf as if he had been struck with a stone or a whip. The muscle becomes rigid and motion is impossible. Often on palpation a small depression may be found in the gastrocnemius. Under rest recovery usually ensues in about three weeks, but active exercise is liable to lead to recurrence of the symptoms. Wharton Hood[7] has noticed that in boys who, in spite of pain and professional instructions, returned to their games at a very early date, recovery ensued more rapidly and satisfactorily than in more docile patients. He thinks that when rest is kept up during healing there is a contraction of the injured fibers and that these are liable to be torn or stretched when active exercise is resumed. Hood advises that the injured limb be elevated for five minutes and then the affected area be snugly strapped with adhesive plaster. The patient must be urged to walk at once, and in walking to let his heel touch the ground. As soon as the strapping becomes loose it must be reapplied. The same principles must be applied to cases of trifling rupture in other localities.

Rider's thigh is a condition entirely similar to the preceding. Here the muscular fibers of the adductors of the thigh are torn to a greater or less degree. There are sudden, sickening pain and tenderness. A groove or depression may be felt in the muscle. There is much ecchymosis and swelling. Treatment by rest generally gives good results, but, as in "lawn-tennis leg," massage and strapping, with early exercise, lead to more rapid and perfect restitution.

When a large part of a muscle is ruptured, a deep groove is palpable in it. A hematoma forms. The proximal fibers contract, and in contracting form a swelling which has often been mistaken for a muscular hernia.[2] The inferior or distal fibers, deprived of their nerve-supply, degenerate. This *pseudo-hernia* may be noticed at the time of the accident or be masked by the hematoma. In many cases, however, it develops slowly, becoming evident only after the lapse of a month or more. The diagnosis of pseudo-hernia is easy if examination is made as follows:

(*a*) The muscle at rest. A pedunculated tumor is felt, softer in consistence than normal muscle, movable from side to side, but not up and down.

(*b*) The muscle passively extended. The consistence of the injured muscle remains the same, while the neighboring muscles being submitted to tension, become firmer. The tumor may lessen in volume.

(*c*) The muscle voluntarily contracted. The tumor becomes larger, harder, more fixed, and moves toward the origin of the muscle (Fig. 313).

(*d*) The muscle voluntarily contracted against opposition. The phenomena noticed are merely an exaggeration of those described under (*c*).

True muscular herniæ are rare, and consist in the protrusion of muscle tissue through an opening in its sheath. They are the result either of injury or disease. They never possess a pedicle. The tumor is prominent when the muscle is at rest (Fig. 314, *a*), disappears when the muscle is passively extended (Fig. 314, *b*), diminishes in size on active motion, and disappears when the muscle is contracted against opposition (Fig. 314, *c*).

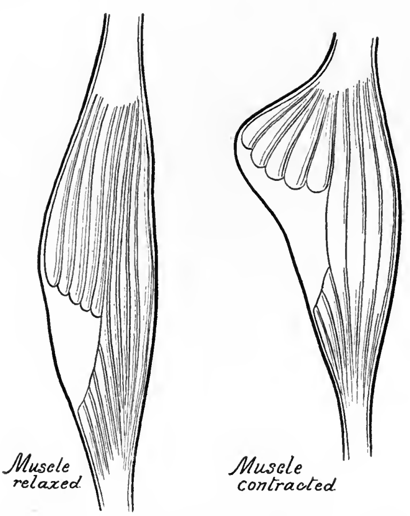


Fig. 313.—False Hernia of Muscle (modified from C. Lyot).

Complete rupture of a muscle presents symptoms similar to those of partial rupture. The separation of the divided portions is well marked.

Treatment of Severe Rupture.—If the rupture is so great that the treatment outlined for "rider's thigh" is evidently improper, a fair result may be obtained by placing the muscle in a position of relaxation and keeping it in this position. Strapping of adhesive plaster applied judiciously will aid in giving rest and in keeping the divided structures more or less approximated. Usually, however, operative treatment is necessary.

Myorrhaphy.—Make an incision corresponding to the long axis of the muscle, and freely expose the injured portion. Remove all blood-clot and detritus. If necessary, trim the torn surfaces so that they may correspond to each other when united. Attend to hemostasis. By posture relieve the muscles from all tension. With thick sutures, preferably of catgut, unite the divided muscle. If the surfaces to be united are large, the sutures ought to be introduced in layers. Each suture should take a deep bite, as cutting loose is common. I usually employ a continuous suture and endeavor to prevent cutting or splitting of the muscle by introducing a few stitches transversely (Fig. 315, *x*). If tension on the principal line of union is feared, one or more relaxation sutures may be employed (Fig. 315, *R.S*). Having united the muscle, close the wound in the fascia and in the skin. If there is danger of infection, employ drainage. The after-treatment consists in keeping the muscle at rest in a position of relaxation for three weeks, after which time motion may be cautiously begun.

The operative treatment of old and neglected cases of muscular rup-

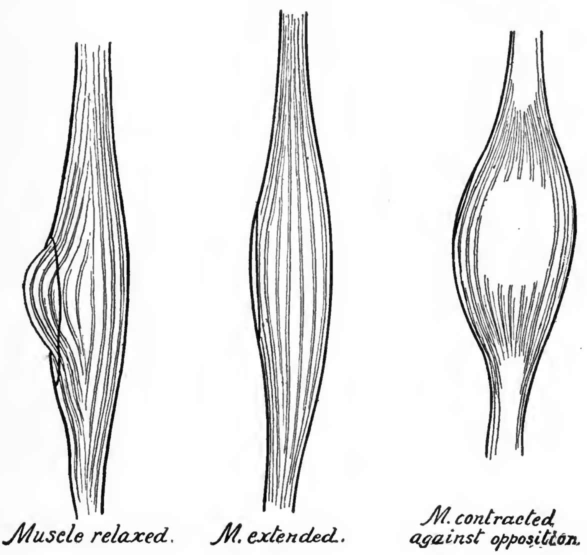


FIG. 314.—TRUE HERNIA OF MUSCLE.
a, Modified from C. Lyot; *b*, *c*, original.

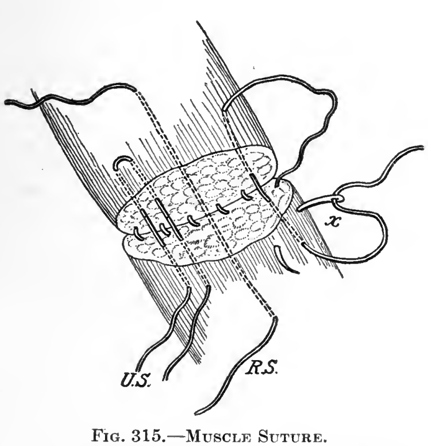


FIG. 315.—MUSCLE SUTURE.
x, Continuous suture, one stitch being introduced horizontally to prevent splitting of the muscle; *R. S.*, relaxation suture; *U. S.*, mattress or U-suture.

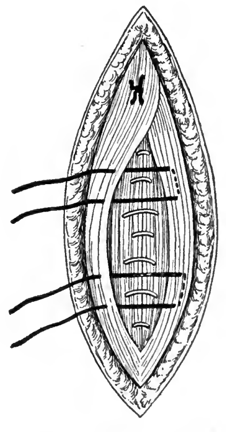


FIG. 316.—TRUE HERNIA OF MUSCLE.
The protruding muscle has been excised and the muscular wound sutured. Note the irregularity of line of suture; this prevents splitting of the muscle. Mattress or U-suture in place to close fascial wound in overlapping fashion.

ture is not very satisfactory. It consists in the excision of scar tissue and in myorrhaphy. When false hernia is present, the tumor may be excised, but after this, recurrence is the rule.

Treatment of True Hernia of Muscle.—When a muscular hernia is causing annoying symptoms, it demands operation. Expose the hernia by an incision. Excise the protruding portion of muscle. Close the wound in the muscle. Undermine the fascia for a short distance around the hernial opening to relieve tension. This is important. Close the hernial opening with sutures, if possible, making one edge overlap the other (Fig. 316). Close the skin wound.

THE TENDONS.

Thecitis or Tenosynovitis.—Inflammations of the tendons and their sheaths must be considered together. The exciting causes of tenosynovitis are numerous, *e. g.*, trauma, pyogenic infection, gout, rheumatism, syphilis, gonorrhea, tuberculosis, etc.

(1) **Traumatic Tenosynovitis (Simple, Non-infective).**—The tendons most commonly affected are those of the wrist or the ankle. As a result usually of overexertion the smooth synovial membrane becomes congested and roughened so that when the tendon moves inside its sheath, a creaking or rubbing is noticeable with more or less pain. The condition is exactly analogous to that found in dry pleuritis. Later an effusion of fluid takes place into the sheath, separating the sheath from the tendon, causing a cessation of the rubbing or crepitation and usually permitting motion with less pain. If the effusion causes much tension, pain and uneasiness may be marked. This stage of the trouble corresponds to that of pleurisy with effusion. The symptoms of simple or traumatic tenosynovitis are obvious. Usually the inflammation subsides promptly on the removal of the cause and complete anatomic and functional recovery takes place. If the cause is not removed, the inflammation may become chronic. In cases of sprain, tenosynovitis is, of course, common, and if the sprain is treated with too much rest, the inflammation may result in the formation of adhesions between the tendon and sheath. On resumption of exercise these adhesions, unless completely broken down and kept from reforming, are liable to be stretched and irritated and thus give rise to chronic tenosynovitis. The complete rupture of such adhesions and the subsequent forcing of exercise have cured many cases of chronic simple tenosynovitis and brought much credit to bone-setters.

Treatment.—Removal of the cause is the prime consideration. When this is done, most cases recover promptly. The use of external applications, such as iodin, ichthyol, etc., is excellent as a *placebo*. Moderate exercise of the tendon is of use to prevent the formation of adhesions. Support to the part, in the form of a wristlet of leather or webbing or of adhesive strapping is comforting and hastens recovery, especially if effusion is present.

(2) **Infective Tenosynovitis.**—Infection may reach the tendon-sheaths through an open wound or through any of the ordinary routes. The commonest sources of infection are a neglected whitlow or an infected punctured wound. Once infection has occurred, the resulting suppurative

inflammation spreads rapidly along the tendon-sheaths, converting them into sacs of pus. The tendons, being poorly nourished structures, are very prone slowly to slough and be discharged with the pus. As the tendon-sheaths of the hand and wrist are the commonest sites of infective teno-synovitis, one must recognize their anatomic arrangement. The flexors of the thumb and little finger are provided with sheaths which communicate directly with those of the palm and wrist, while the sheaths belonging to the flexors of the other fingers have no such connection with the palm (Figs. 317, 318). It is evident, from the above that thecitis of the flexors of the thumb and little finger can spread unopposed under the annular ligament of the wrist, and invade even the whole forearm.

The symptoms of thecitis are swelling and redness, with intense pain and tenderness along the course of the tendon. When the synovial sheaths at the wrist are affected, the resistant annular ligament gives the swelling a dumb-bell shape. Red lines may be seen running up the limb (lymphangitis) to the corresponding lymph-glands, which may become involved in the inflammation (lymphadenitis) and may break down into secondary abscesses. Constitutional symptoms are often severe.

Fig. 317.—Palmar Synovial Sheaths. Normal Form.

Treatment.—As soon as the diagnosis of infective tenosynovitis is made, the classical treatment is operative.* If possible, incise *before* suppuration has developed. When pus is present, very free drainage must be provided. Two or more incisions, large enough to admit easily a rubber tube about the size of a No. 21 French catheter, are better than a single large opening. When incising the palm of the hand, remember the palmar arches. These may be avoided by cutting distal to a line drawn across the palm at the level of the web of the thumb. The after-treatment consists in cleanliness and the use of a splint to give rest.

Neglected cases or those in which infection is particularly virulent may not respond to the above treatment; in these, spread of the inflam-

* Bier's method of treatment is described under Palmar Abscess.

mation may even call for amputation. The vital dangers of infective tenosynovitis are septic intoxication, septicemia, and pyemia. The local dangers are the various deformities, contractions, and disabilities due to sloughing and scar formation.

It is necessary to mention one or two special forms of infective thecitis.

Gonorrheal Tenosynovitis.—The pathologic anatomy of this infection is practically the same as that of acute infectious disease. It may arise at almost any period of the urethral disease, and may be acute or subacute. Edema of the tissues around the affected tendon-sheath is an early symptom. The pain, loss of function, marked evidences of inflammation, etc., occurring in a young and healthy individual ought to arouse suspicions, and when the history of urethritis is elicited, the diagnosis becomes reasonably sure.

FIG. 318.—PALMAR SYNOVIAL SHEATHS. FREQUENT FORM.

Treatment.—The classical treatment is absolute rest. When a limb is affected, rest is obtained by the use of a splint and elevation. Cold or hot applications may be employed. Various ointments or lotions are reputed valuable, probably mostly as placebos. When the pain and swelling are very great, multiple *small* incisions or punctures give great relief by permitting the escape of the inflammatory effusion. Friedrich[8] considers this the only operative treatment required. The incisions or punctures must be made with care and kept clean, lest secondary infection occur. As soon as the acute symptoms subside and pain is relieved, active and passive motion must be begun, otherwise disabling adhesions are almost certain to form. Bier's method of treatment has given good results. (See Palmar Abscess, p. 454.)

Syphilitic tenosynovitis may arise either early or late in the disease. When an early manifestation, the lesions usually belong to the type hydrops (*vide infra*); when a late manifestation, they consist of gummata of the sheath. The diagnosis of both forms must depend on the presence of other stigmata of syphilis. Under specific medication recovery soon ensues.

Tuberculous Tenosynovitis (*Compound Ganglion; Hygroma of Tendon-sheath; Hydrops Tendovaginitis*).—Like any other synovial membrane, the tendon-sheaths may become tuberculous. On section the sheath is found to consist of three layers. The outer layer consists of fibrous tissue, more or less inflamed, the middle of granulation tissue studded with tuberculous nodules (this layer is the active seat of the disease); the inner layer consists of a deposit of fibrin varying in thickness. When the granulation tissue is present in great abundance, it may fill up and distend the tendon-sheath, causing a marked doughy swelling. The tuberculous granulation tissue is prone to caseate and cold abscess may result. This is the fungous form of tuberculous tenosynovitis.

When the granulation tissue is moderate in quantity but there is much effusion of fluid into the tendon-sheath, the name hydrops is given to the disease. The fluid contained in the diseased sheath is rich in coagulable material; from this is derived the fibrinous layer of the sheath wall. Fibrin may also be deposited on the normal synovial villi or fringes, forming these bodies into small pedunculated tumors. In the course of the disease the tendon itself becomes frayed to a greater or less extent, and fibrin, deposited on the projecting fibers of tendon, form similar pedunculated tumors. The commonest method by which rice bodies (melon-seed bodies, oryzoid bodies, etc.) are formed is by this coagulation of effused fluid.

Fig. 319.—Rice or Melon-seed Bodies from Tuberculous Palmar Hygroma.
Many of the bodies show pedicles.

Motion of the tendon in the sheath often has a great effect on the coagulation. The coagula as they form are moved about and become oval. The rice bodies vary from the size of a millet to that of a melon seed. They are elastic, yellowish, and opalescent in appearance and may be very numerous (Fig. 319). On section, they are found to consist of lamellæ surrounding a granular or fibrous center. Rice bodies usually float loose in the fluid, but they may be attached to the surface either of the sheath or tendon. Some pathologists believe them to be the product of coagulative *necrosis* of the synovialis, but the explanation given above seems to be the true one in most cases. It is, however, entirely possible that they may be formed in several ways.[9, 10, 11, 12, 13] Tubercle bacilli are present in small numbers in the granulation tissue, in the effused fluid, and in the rice bodies. Tuberculous tenosynovitis may arise from infection through the blood-stream or from extension from neighboring foci of disease. This latter is particularly common in the fingers where an osteal focus may exist without giving rise to symptoms, spread to the tendon-sheath, and occasion gross lesions there. Unless the primary disease is discovered and cured, there will be recurrence no matter how the tenosynovitis is treated. The tendon itself may be invaded and destroyed by the disease, especially in the fungous form. In rare cases of diffuse tuberculous thecitis much fibrin may be deposited on the sheath wall in one or more places, and *pari passu* the tuberculous granulation tissue invades and substitutes itself for the fibrin. Thus a tumor is formed which distends and follows the course of the sheath. During operation, the sheath is found full of a brownish-red mass of young connective tissue richly peppered with tubercles. These tumors[9] may be the size of a hazel-nut or larger, and may extend into the tendon-sheaths of the fingers. The course of the disease is very slow; the dangers are from metastasis and from spontaneous opening and secondary infection. The commonest site of tuberculous tenosynovitis is on the palmar aspect of the wrist. In this location the annular ligament gives an hour-glass appearance to the swelling. On palpation in the fungous variety one finds a doughy swelling; in the exudative form there is fluctuation, and when rice bodies are present there is distinct and characteristic crepitation. Absence of pain is the rule.

Treatment.—Fungous Variety.—A. (*a*) Incision; (*b*) thorough curettage; (*c*) thorough swabbing of the cavity with tincture of iodin; (*d*) thorough iodoformization; (*e*) drainage; (*f*) application of dressings and splint. This treatment often gives good results, but is not nearly so satisfactory as the following:

B. (*a*) Application of Esmarch bandage; (*b*) free exposure of the whole of the diseased structures, dividing, *e. g.*, in the palm, the annular ligament; (*c*) careful sharp dissection and removal of all diseased tissue; (*d*) thorough iodoformization of the wound; (*e*) closure of the wound after providing for drainage (if such structures as the annular ligament have been divided, they must be carefully sutured); (*f*) application of dressings and splint.

Exudative Variety.—A. If it is believed that rice bodies are absent—(*a*) Evacuate the fluid through a cannula or small incision; (*b*) irrigate the cavity with salt solution; (*c*) fill the cavity with iodoform emulsion (5 per cent.); (*d*) dress and apply splint.

B. If the above method fails or if rice bodies are present—(*a*) Incise the sac sufficiently to give easy access; (*b*) evacuate the fluid and rice bodies, using, if necessary, a curette; (*c*) irrigate with salt solution or with a sherry-colored solution of tincture of iodin in water; (*d*) fill the cavity with iodoform emulsion (5 per cent.); (*e*) close the wound and apply dressings and a splint.

C. If the methods A and B fail, it becomes necessary to excise all the diseased synovialis.

Tumors of Tendon-sheaths.—The tendon-sheaths are subject to the same neoplasms as are other connective tissues. Of these, lipomata are by far the most usual. The tumors may grow either on the outer or inner side of the sheath; in the latter position they are liable to surround the tendons and follow them toward their insertion. This is especially true of lipomata growing in the palmar bursa, where the tumor may become elongated and branched (lipoma arborescens).

The rules applicable to the diagnosis of tumors in general must be employed here as elsewhere, but errors will be frequent, as the growths may accurately mimic the lesions of tuberculosis.

The treatment consists in excision.

Paronychia or **panaritium** is an infective inflammation under the skin surrounding the nail. The infection enters through a scratch or a hang-nail. If resolution does not occur at an early stage, suppuration takes place, raising the epidermis as a blister. The process may spread under the nail, causing its death. If neglected, the disease may increase and develop into a felon or whitlow. The symptoms of paronychia are obvious. The treatment consists in rest, cleanliness, and cold applications. When pus is present, it must be evacuated by incision. Dead portions of skin must be trimmed off. If pus is present beneath the nail, it may be drained by boring a hole through that structure; as, however, the nail is almost sure to die, it is better freely to remove the undermined portion and so obtain better drainage. In any case the dressings ought to be kept wet.

FIG. 320.—SKIAGRAPH OF OSTEOMA IN TENDO ACHILLIS (Finney).

Whitlow—Felon.—These names are applied to acute inflammations of the fingers which usually end in abscess. The cause of whitlow is, of course, bacterial, but trauma often acts by locally lowering resistance. The necessary infection usually gains entrance through a scratch, prick, or any wound, but it may also enter by the blood-stream. The primary lesion may be situated in the skin itself (furuncle, boil); in the subcutaneous tissue—here very dense (phlegmon); in the tendon or its sheath (tenosynovitis); or in the periosteum or bone (periostitis, osteomyelitis). In neglected cases, no matter what the site of the primary lesion, any or all of the above structures are liable to become involved; for example, a subcutaneous lesion may be accompanied by periostitis while the tendon-sheath may escape intact. Lymphatic absorption is liable to lead to palmar abscess and metastasis in the arm or axilla. When the tendon-sheath is involved, the disease spreads rapidly; the tendon is likely to die and slough off. When the periosteum or bone is involved, necrosis of the latter is common, and one or more articulations may become affected. The tissues of the finger being very firm and rigid, a small amount of swelling causes much tension, intense throbbing pain, which prevents sleep, and causes early sloughing of the involved structures.

Symptoms.—The most prominent symptom is pain. This is often throbbing in character. The throbbing may be noticeable on palpation. A dependent position increases the pain. Tenderness is great and is most marked over the principal site of the disease, thus affording a guide, when an early incision is made. Redness, heat, swelling, and impairment of function are, of course, in evidence. Fluctuation is rarely present, at least in the early stages; this is due to the density of the subcutaneous tissue. The great tension present in the inflamed region leads to early and pronounced absorption, so that the temperature is elevated and the pulse accelerated to a degree out of proportion to the extent of the lesion.

Terminations.—Resolution is rare. Unless tension is relieved and drainage is provided by the surgeon, the disease spreads, the pus burrows in all directions—incidentally through the skin; various structures, such as tendon and bone, die and slough off. If recovery supervenes, so much and such important tissue has been destroyed that great and permanent deformity and disability result.

Treatment.—At a very early stage cold or hot applications may be used, and, what is more important, the part affected should be kept elevated and at rest. These measures will rarely be effective. *The treatment for whitlow is early incision.*

It is not always easy to determine where to incise in an early case. The best guide to the site of trouble is tenderness, which may be elicited by pressure with a probe or such like instrument. The most tender spot is usually the site of the most active disease. The old method of incising a whitlow was to cut directly to the bone in every case. This practice is capable of doing much harm, as by it one is liable to carry infection into tissues not yet contaminated. Under a local or general anesthetic make an incision through the skin, to one side of the tendon, unless the tendon is evidently affected. Guided by the eye, continue cutting slowly until the focus of inflammation is reached. Avoid injuring the tendon-sheath or the periosteum, if these structures are intact; if involved in the disease, they must, of course, be incised. With a small curette remove all gross infected material. Clean the wound with an antiseptic solution. It is good surgery to swab the infected area with liquid carbolic acid, neutralizing the acid by wiping with alcohol immediately afterward. Provide drainage and apply moist antiseptic dressings.

The methods of Ochsner and of Bier are referred to in the section on Palmar Abscess.

Palmar Abscesses.—Palmar abscesses are the result of infection which enters through a wound or abrasion of the skin, through the lymphatics, *e. g.*, from an infected finger, or through the blood-current. Trauma frequently acts as an exciting cause. Palmar abscess most frequently results from suppurative tenosynovitis. The symptoms are those usual to abscess; the pain and tenderness are intense; fluctuation is usually absent because of the density of the palmar fascia. A. Broca describes a puzzling variety of palmar abscess. Infection gaining entrance through a wound on the finger passes to a bursa which lies under the callus over the head of a metacarpal bone, and there produces a phlegmon. The symptoms and signs of the inflammation consist of redness and swelling on the *back* of the hand, principally at an interdigital commissure and at the side of the first phalanx of the infected finger. Pressure on the head of the metacarpal causes pain; so does extension of the finger. Incision at the site of the greatest redness and swelling is not efficacious; it is necessary to incise the inflamed bursa on the palmar aspect of the head of the metacarpal bone.

Treatment.—In recent cases, where the symptoms are not severe, hot or cold applications may give some relief, but when pus has formed, incision must not be delayed. The dangers incident to incision are injury to the palmar arch or to some of the flexor tendons. The tendons may be avoided by cutting in the long axis of the limb and doing it deliberately. The palmar arch may be avoided by incising distal to a horizontal line drawn across the palm at the level of the web of the thumb. If it is necessary to incise above this line, do so as follows:

Cut through the skin alone, thus exposing the fascia; carefully divide the deep fascia. Push a fine-pointed hemostat through the tissues into the pus and open the blades, thus tearing the deep tissues and pushing the blood-vessels aside. After evacuating the pus, provide drainage, preferably tubular. If necessary, make counter-openings.

Tubes split longitudinally are advisable, as they are soft and do not cause injurious pressure. Pressure from a tube on the palmar arch has caused necrosis and serious hemorrhage. The methods devised by Bier for treating various forms of inflammation by means of hyperemia have obtained so much support throughout both Germany and France that they demand consideration. These methods, it is admitted, are not applicable to cases of streptococcic infection; they are of special value in the treatment of phlegmonous tenosynovitis and of whitlow.

When treating the hand, wrist, or forearm by passive hyperemia, apply a thin, cheap rubber bandage around about one-third of the upper arm; in the case of the foot or leg, apply a better grade of bandages around the thigh. Apply the bandage tightly enough to produce marked hyperemia and edema, especially at the site of disease, but never tightly enough to cause pain or even paresthesia. The limb below the bandages must never be cold or feel cold. If the patient is interested in a book or a conversation, he ought to be able to forget the presence of the bandage. The hyperemia ought never to cause pain—it ought to relieve it. In acute inflammations (not in tuberculosis) leave the bandage *in situ* for twenty to twenty-two hours. When the bandage is removed, elevate the limb and wash the skin which was covered by the bandage with alcohol. If pus is present, evacuate it through small incisions, but do not use drainage, either tubular or gauze.

If the disease affects the tendons of the hand or foot, move every joint in the involved area either actively or passively at frequent intervals.

Instead of producing hyperemia by a bandage, Bier and Klapp have obtained the same and, in some cases, better results by suction. For lesions such as palmar abscess an ordinary cupping-glass, provided with a rubber bulb for suction, suffices. For the finger, hand, arm, foot, etc., special but simple apparatus is necessary. When pus is present, evacuate it through small incisions or punctures, and at every treatment see that these openings are patent.

When large apparatus is used to produce hyperemia, *e. g.*, in the arm, it is well to apply cupping-glasses to all sinuses and suck out the pus as a preliminary to the regular treatment.

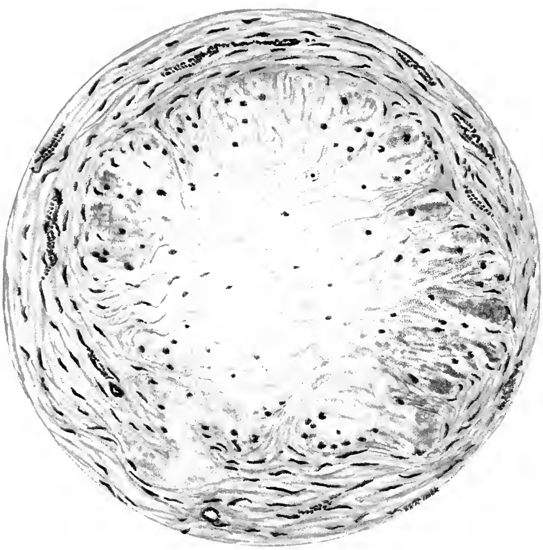
Produce enough vacuum in the apparatus to cause marked edema and hyperemia, but there must neither be pain nor paresthesia. Apply suction for periods of five minutes, alternating with three-minute periods of rest. This alternate suction and rest must be kept up for about forty-five minutes daily. Except when being treated as above, cover the inflamed parts with suitable dressings.

Ochsner,[14] in cases of felon and of palmar abscess, believes that it is better to operate a little late rather than too early. According to him, if absolute rest is given to the arm and moist heat be applied in the form of a very large antiseptic fomentation, resolution becomes the rule, and if an abscess forms, it will be well localized and easily evacuated.

FIG. 321.—GANGLION.

Ganglion.—Ganglia are cystic tumors varying from the size of a pea to that of a plum. Their favorite site is in the dorsal carpal region, but they may appear in the palm near the metacarpophalangeal articulation. In this latter situation they are commonly overlooked. Occasionally they are seen on the dorsum of the foot. Ebner describes one which was located on the external semilunar cartilage of the knee. The contents consist of a clear or straw-colored, jelly-like material. Formerly ganglia were considered as herniæ of the synovialis of joints or tendons, but thanks to the researches of Ledderhose,[15] Thorn,[16] Franz,[17] and others, we now know them to be products of connective-tissue degeneration. The connective tissue adjoining the joints or tendons becomes more cellular than usual, possibly as the result of trauma. Throughout this proliferating tissue foci of collagenous degeneration become apparent and form minute cysts. As the cysts increase in size the strata of tissue separating them undergo a similar degeneration and liquefaction (Plate VII), so that at length a multilocular cyst becomes monolocular. In one or two reported cases a ganglion has been formed in the above manner inside a tendon.[18] The cysts often communicate with an articular cavity or tendon-sheath, but these communications are secondary. The disease

PLATE VII.



SECTION OF SMALL GANGLION OF WRIST. Collagenous degeneration not far advanced.

is most common among adolescents. The tumors may vary in size from time to time and even disappear entirely.

Symptoms.—Pain, usually slight, is often noted, but it may be entirely absent. A feeling of weakness in the affected wrist is very common. On examination, a tumor is observed over which the skin moves freely (Fig. 321). The tumor is usually immovably attached to the subjacent structures, though when it arises from the connective tissue of a tendon-sheath it can be moved laterally.

In ganglia, while the progress of degeneration is still going on in several foci, palpation reveals an almost bony hardness; when the degeneration is complete and a single cyst is formed, fluctuation may be observed.

Treatment.—Dispersion of the cyst contents into the surrounding tissues, whence they are absorbed, has given many good results. This dispersion is accomplished by laying the affected member on a firm support and hitting the ganglion a sharp blow with a heavy book, thus rupturing it. The after-treatment consists in applying firm pressure to the part by means of a pad and bandage. The same result may be more elegantly obtained by puncturing the cyst with a tenotome and letting the contents escape along side of the blade; subsequently pressure must be applied. Some surgeons have injected the cyst with iodin or iodoform emulsion after evacuation, but this does not seem to have given better results. Evacuation or dispersion of the cyst contents is most suitable in cases of monolocular cysts, *i. e.*, where the degenerative process is practically complete. Aseptic excision of the ganglion is the treatment most in vogue to-day. It is suitable in early as well as late cases. The excision must be thorough, especially where the degenerative process has not come to a standstill.

Whatever treatment is adopted, recurrence is frequent. The disease is annoying, rather than serious. Small ganglia and those which cause neither annoyance nor deformity are best treated with contempt.

Wounds of Tendons.—Wounds of tendons may be punctured, subcutaneous, or open. *Punctured wounds*, in the absence of infection, are of no importance. *Subcutaneous wounds* are almost all inflicted by the surgeon for therapeutic purposes. (See Tenotomy.) In cases of subcutaneous wounds resulting from accident the injured tendon must be exposed and treated as if it was primarily an open wound.

Open Wounds.—Open wounds of tendons are very common, especially about the fingers, hands, and feet. The trauma may be cutting, crushing, or tearing, the character of the wound varying with the cause. In cuts one or more tendons are more or less neatly divided. In crushes, the tendon is bruised, split, and frayed. In tears, the tendon separation may be at a point remote from the open wound, *e. g.*, the thumb or a finger is torn off by machinery, the bony flexor tendons are pulled out of their sheaths, their insertions into the fingers are intact, but they themselves are ruptured at their junction with the muscles; in fact, fragments of muscle may be seen attached to them. Where a tendon is divided, that portion attached to the muscle retracts. The amount of retraction varies according to the presence or absence of a tendon-sheath and according to the fibrous connections of the tendon. The tendon of the extensor longus pollicis has a sheath which is free from fibrous connections, hence when divided, it may retract as much as 6 to 10 cm.[2]

The flexors of the fingers have tendon-sheaths, and if divided near the wrist, they may retract 3 or 4 cm. On the back of the hand there are fibrous connections existing between the extensor tendons of the fingers, and hence, when these are divided, retraction is slight.

Complete section of the tendo patellæ permits of little retraction of the quadriceps because of the lateral expansion of the tendon about the knee-joint; complete section of the tendon above the patella permits of great retraction.

Repair of tendons is similar to repair of other fibrous structures. The space between the divided ends of the tendon becomes filled with blood and lymph, which serve as a scaffold to support the granulation tissue which grows into and replaces it. The granulation tissue is derived both from the wounded tendon and from its sheath. It takes about sixty days[2] for the granulation tissue to become mature, *i. e.*, for repair to be complete. The less gap there is between the divided ends of the tendon, the better chance there is of efficient repair. If the gap is too great, repair is impossible. If there has been much injury to the tissues surrounding the divided tendon, and especially if there has been infection, the reparative process is liable to fuse all the involved structures into a functionless, deforming scar.

Infection of tendon wounds is always serious; it is especially so when the tendon is provided with a sheath, since the pus may travel up the sheath.

Symptoms.—When the external wound is large, it is usually easy to see what tendons are divided. When there is only a small external opening or if the injury is subcutaneous, loss of function and the signs of tendon rupture ought to make the diagnosis easy.

Treatment.—The ordinary principles of wound treatment must be carried out with scrupulous care, because infection in non-resistant structures, like tendons, has such disastrous results. Every tendon which is divided by accident demands immediate suture or secondary suture if seen later. If several neighboring tendons, *e. g.*, at the wrist, are divided, care must be taken to unite the two ends of the *same* tendon.

Methods of Tendon Suture (Tenorrhaphy).—A round, intestinal needle is better than the ordinary surgical one.

Suture Material.—Chromicized catgut, celluloid hemp, silk, silkworm gut, silver wire, kangaroo tendon, etc. The best methods of applying the sutures are shown in Figs. 322, 323, 324, 325, 326, and 327. The various complications in the methods are devised to prevent the cutting or splitting of the tendon by the suture.

If it is impossible to bring the ends of the tendon into apposition without tension because of loss of substance, retraction, etc., various means of tendon lengthening must be employed. Figs. 328, 329, and 330 show the best known methods. If the above means are inapplicable, the gap may be filled with some suture material or with a graft. Figs.

331, 332 show the application of such sutures. A number of strands of catgut or of catgut and silk may be formed into a small cable, the ends of which may be sutured to the divided ends of the tendon. This "cable" merely forms a framework into which grows tendon tissue or a substitute therefor. If two neighboring tendons are in part destroyed by the same accident, a portion of the less important one may be used to replace the defect in the more important.

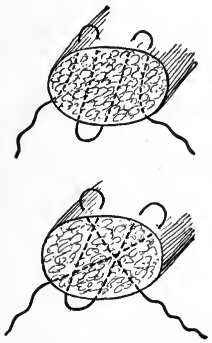


Fig. 322.—Suture Transfixes Tendons in Various Directions.

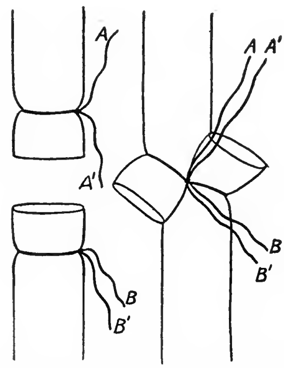


Fig. 323.—The Suture Introduced as in Fig. 322, is Tied Around the Tendon Like a Ligature; the Ends are Left Long—AA', BB'.

The suture AA' is tied to BB' and a lateral approximation obtained which, after healing, is indistinguishable from end-to-end union.

Before suturing a divided tendon it is necessary to bring the ends into apposition. This may be difficult because of retraction. There are several methods for finding the retracted portion:

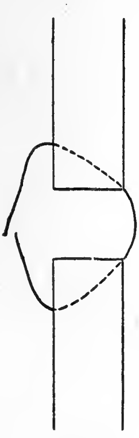


Fig. 324.

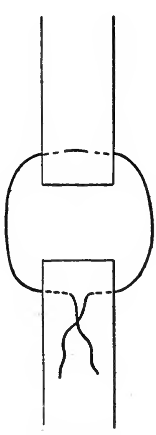


Fig. 325.

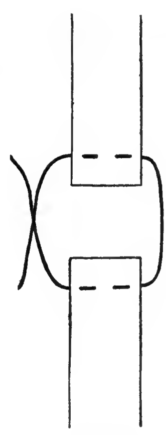


Fig. 326.

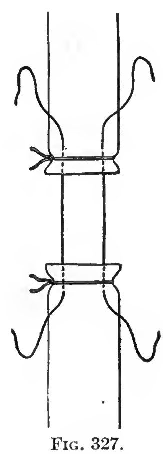


Fig. 327.

(*a*) Pass a forceps up the sheath, seize the tendon, and pull it down. This often fails.

(*b*) Pass a probe up the sheath until it touches the tendon. Incise the sheath over the end of the probe. Introduce a suture through the tendon. Pass the suture on a probe or blunt needle through the sheath, and make it emerge at the primary wound. By means of the suture pull the tendon down into position.

(*c*) Split the sheath upward until the tendon is exposed.

(*d*) Force the tendon downward by methodically pressing the muscular belly downward or by applying an elastic bandage around the limb from the origin of the muscle downward. If, after thorough and extensive search, the upper end of the tendon cannot be found, unite the distal segment to some neighboring tendon by the methods shown in Fig. 333, *a*, *b*, and *c*. If the proximal end of the tendon is accessible but the distal is lost or destroyed, several means of treatment are available. (*a*) Suture the end of the tendon to the side of a neighboring tendon. (*b*) Suture the end of the tendon to the periosteum or bone at a point as near

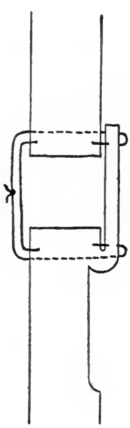


FIG. 328.

FIG. 329.

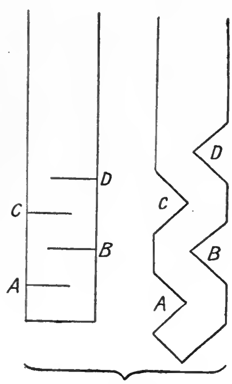


FIG. 330.

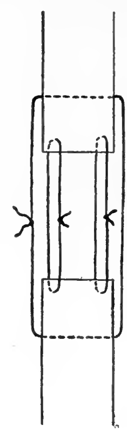


FIG. 331.

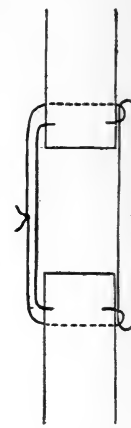


FIG. 332.

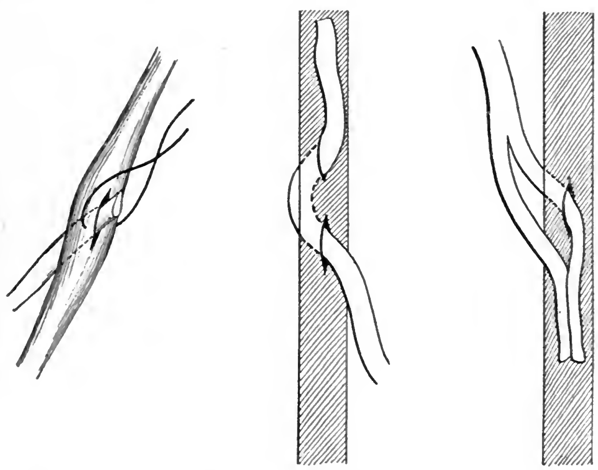
as possible to its normal insertion. (*c*) Unite the tendon to the bone or periosteum by means of a catgut or silk graft.

Method of Uniting a Tendon to Bone or Periosteum.—(*a*) *Lange's Method.*—At the site chosen for implanting the tendon raise a flap of periosteum, $\frac{1}{4}$ to $\frac{3}{4}$ inch in length. Suture the tendon to this. If the tendon is not long enough, use a double suture of silk as a graft.

(*b*) *Wolff's Method.*—Divide the periosteum at the site selected. Reflect it to each side. With a chisel cut a groove in the exposed bone. Place the tendon in the groove. Replace the periosteal flaps over the tendon, suturing them together and to the tendon. After having united the divided tendons close the original wound if possible, without drainage. If the wound is evidently infected when it is first seen, it is wise to treat it by the open method until the infection is overcome and to unite the tendons at a later sitting.

After-treatment.—Apply plenty of dressings. Fix the parts by splints or plaster-of-Paris in such a position that tension on the sutures is relaxed. Make no attempt at motion for two weeks in the case of smaller tendons; in the case of larger tendons or where grafts have been employed a longer period of rest is necessary. When union is complete, passive and then active motion must be begun, aided by massage and electric stimulation.

Rupture of a Tendon.—If a tendon receives a sharp blow when it is tense, rupture may occur. A more usual cause of rupture is a sudden strain and a spasmodic contraction of the corresponding muscle, *e. g.*, a man in walking slips, the involuntary muscular efforts made to avoid falling frequently cause rupture of the patellar or of the quadriceps tendon. A tendon weakened by disease is much more liable to injury than one in health. Ritschl mentions the following as predisposing causes: (*a*) Inflammatory hydrops (Volkmann). (*b*) Lipomata in the tendon-sheath (Witzel, Haumann). (*c*) Trophic disturbances in tabes



a *b* *c*

Fig. 333.—Methods of Implanting One Tendon into Another (Vulpius).

and syringomyelia (Lowenfeld, Hofmann). (*d*) Arthritis of the knee (Rohl).

I have seen rupture of the long head of the biceps, weakened by tuberculosis of the shoulder-joint, and rupture of the extensor longus pollicis from a trivial accident following traumatic tenosynovitis. The commonest sites of rupture are in the quadriceps tendon, either above or below the patella, the tendo Achillis, and the biceps or the triceps tendon in the arm. Usually the wound in the tendon is uniform, but it may be irregular. The latter is true of the quadriceps tendon above the knee. This tendon is composed of fibers running in different planes, due, of course, to the different muscles which act through it. The main rupture is usually close to the patella. Poirier[20] describes a case in which the fibers coming from the rectus femoris were ruptured transversely just above the knee (superficial portion of the quadriceps tendon); under this there was a vertical separation of the fibers coming down from the vasti (middle portion of tendon), deeper still, and 8 cm. above the patella, the fibers coming from the crureus were ruptured. When a tendon is completely ruptured in the above fashion, the wound is irregular and portions of torn tissue are liable to curl inward and interfere with union, as Macewen described the periosteum doing in transverse fracture of the patella.

The rupture may be partial, *e. g.*, in the quadriceps that portion belonging to the rectus femoris alone may be torn. In such a case non-operative treatment may be followed with a good result.

Symptoms.—After an effort, usually violent, a snap may be both felt and heard. This is accompanied by very acute pain. There is immediate and complete loss of function of the corresponding muscle. If the injury is in the lower extremity, the patient generally falls. On examination a depression is seen and a gap felt between the ends of the tendon. Swelling and ecchymosis soon appear. If the quadriceps is ruptured above the patella, the knee-joint is surely opened and there are hemorrhage and effusion into the joint. Effusion into the joint is also present in rupture of the tendo patellæ. In such cases the patella is displaced. When the long head of the biceps is ruptured, Pagenstecher's symptom may be present, *i. e.*, an anterior and upward dislocation of the head of the humerus. This symptom is not constant. Hueter's symptom should be looked for, viz., less forcible flexion of the elbow when the forearm is supine than when it is prone. In Keen's case on flexion of the forearm against resistance, "the biceps' belly terminated at its upper portion suddenly" and felt very flabby and soft. The disability due to the accident was about 25 per cent.[21] In Da Costa's case flexion caused the short head of the biceps to become unduly prominent, though flabby.[21] In rupture of the extensor longus pollicis (drummer's paralysis), extension of the thumb is impossible and the "anatomic or Aristotle snuff-box" is obliterated. On the whole, diagnosis is easy.

Treatment.—If, by means of position and apparatus, it is possible to keep the ends of the ruptured tendon in apposition, this treatment will suffice. When there is much separation of the fragments, operation will be necessary. Operative treatment may be primary or secondary. If primary, it merely consists in exposure by incision and union by suture. In a case where the long tendon of the biceps was ruptured near its origin and direct union was impossible, Da Costa sutured it to the short head of the muscle, with a perfect result.[21] The secondary operation may be much more complicated. The ends of the tendon will be found adherent to a mass of scar tissue, which, in turn, is firmly adherent to surrounding structures. Before the vivified ends of the tendon are united this mass of firm, hard tissue must be thoroughly excised and adhesions which prevent approximation and gliding of the tendons must be broken down. When it seemed impossible to obtain a satisfactory result by excising the scar tissue in a case in which the distal portion of the flexor of the index-finger was adherent to the cicatrix, Chassaignac sought for, found, and united the proximal portion of the tendon to the scar close to the distal portion (tendocutaneous suture).[22]

In rare cases approximation of the fragments after rupture of the quadriceps tendon or tendo Achillis may be impossible without transplantation of their osseous insertion (Bergmann, Poncet). In the case of the quadriceps the operation may be performed as follows:

Expose the parts by a vertical or crucial incision. With a chisel separate the tibial tuberosity, and with it the ligamentum patellæ, from the tibia (Fig. 334). Sever any adhesions which prevent approximation. Suture the rupture in the quadriceps. The separated tibial tuberosity has now slipped upward and assumed a new position on the surface of the tibia. Fix it here by means of a buried ivory peg or by a steel nail which is left protruding through the skin wound, to be removed after union has been secured. Similar procedures may be employed in cases where there is much loss of substance in the tendo Achillis or in the tendon of the triceps brachialis.

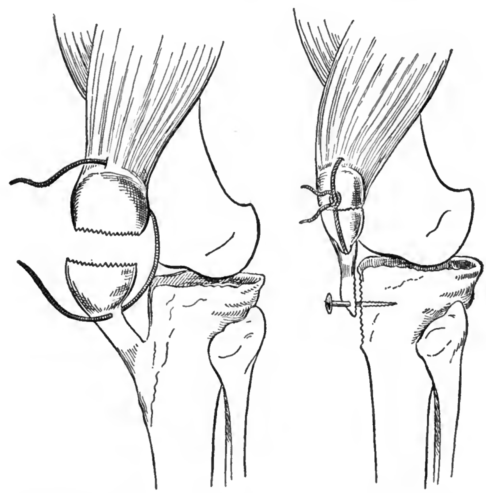


Fig. 334.—Suture of Fractured Patella (Monod and Vanverts).

Suture of the patella is here shown. The principle of operation is identical when suture of the quadriceps is required.

Transplantation of Tendons.—A lack of muscular balance may exist around a joint, due to a loss of power (paralysis) of a muscle or group of muscles or to spastic contraction of a muscle or group of muscles. For example, paralysis of the extensors of the toes creates such a lack of balance about the ankle, and talipes equinus results. Paralysis of the quadriceps femoris leads to a deforming flexion of the knee; spastic contraction of the hamstrings does the same. Formerly treatment was directed toward the contracted or the non-paralyzed muscles, which were lengthened by tenotomy or some plastic operation. Various methods of tendon transplantation are today in use to restore the lost balance of power by reinforcing the weaker or paralyzed muscles at the expense of their healthy neighbors.

The commonest cause of paralysis requiring tendon transplantation is acute poliomyelitis, and as recovery from this is very common, no operation is justified before the lapse of six or nine months. In planning for tendon transplantation we must discover, first, what tendons require assistance, and, second, whence assistance may be obtained. Electric tests are not of much value (Vulpius[23]) because weak currents do not stimulate sufficiently, while stronger ones excite neighboring or even antagonistic muscles. Adults can help us by demonstrating which muscles they can voluntarily contract, while children we can watch at play—stimulating certain muscles by tickling, etc. Deformities must be corrected before transplantation is done, otherwise the latter may be valueless. The methods of operating will be found in the chapter on Orthopedic Surgery.

Luxation of Tendons.—The dislocation of a tendon is a rare accident. Kramer[24] reported a congenital luxation of the peronei in a child of eight months in whom the external annular ligament and the peroneal groove were defective. The peronei tendons are those usually dislocated. Out of eighteen cases where one or the other was involved, in thirteen it was the longus (Beach[25]). The accident is usually the result of a sudden motion in running, dancing, or jumping. According to the experiments of Schneider and Kraske[26] the sequence of events is slight supination, followed by forced abduction and flexion of the foot. The external annular ligament must be torn before the tendons can escape from their groove. Shallowness of the retromalleolar groove predisposes to the accident.

The **symptoms** are severe pain and a sensation of tearing, followed by inability to use the foot. Soon swelling and ecchymosis are evident over and around the external malleolus. Before the swelling appears or after it disappears it is easy to palpate the tendons over the malleolus. Reduction is usually easy, but on the least motion the luxation recurs. Unless promptly and properly treated, the dislocation persists and the retromalleolar groove becomes filled with fibrous tissue. When recovery is imperfect, recurrence may be frequent and result in great disability. It is said that some people are able voluntarily to dislocate and reduce the peroneal tendons; as reduction is completed there is a sharp, rapping noise. This accomplishment is valuable to the "spirit rappers."

Treatment.—Elevate the limb. If swelling is present, practise massage. Reduce the dislocation. Keep the tendon in place by means of a pad and bandage or by means of adhesive strapping applied as in sprained ankle. Rest for four to six weeks is usually advised to permit healing of the ruptured ligament. Should it prove difficult to retain the tendon in proper position, operation is required. The same is true in cases of persistent or recurrent luxation where disability results.

The Operation.—Expose the tendon by an appropriate incision, usually curved so as to form a flap. Place the tendon in its groove; find the remnants of the external annular ligament and suture them over the tendon. Close the wound, dress, apply a plaster-of-Paris bandage. In old cases the groove may be filled with fibrous tissue and the remnants of the ligament may be undiscoverable or insufficient. Under these circumstances reconstruct the groove, replace the tendon, cover the tendon with any fascia which may be present and be suitable to replace the ligament. If no suitable fascia is available, König[5] and others form a flap of bone and periosteum from the outer side of the fibula, turn this back over the tendon, and suture it to the remnants of the annular ligament or to the periosteum of the os calcis.

Luxations of a few other tendons have been described. As a result of sudden contraction of the tibialis posticus its tendon became dislocated and lay between the skin and the internal malleolus (Martin). Haberern[27] reports one case of luxation of the extensor of the index-finger due to a fall on the prone and extended hand. On attempted extension the finger deviated toward the little finger, and extension was only possible to 130 degrees. The abnormal course of the tendon was easily palpated. A new sheath for the tendon was made from the capsular ligament of the metacarpophalangeal joint. The result was good.

Luxation of the long tendon of the biceps has been described. It is difficult to imagine this injury occurring without dislocation or fracture of the head of the humerus.

Tendinitis Achillea Traumatica.—Schanz[29] describes a condition often mistaken for, but commoner than, Albert's disease. After indulging in bicycling or mountain climbing the patient complains of a painful swelling of the tendo Achillis, limps, turns his toes outward, and feels better when wearing high-heeled shoes. There is no bursitis. The tenderness and swelling are in the tendon itself, not at its insertion. Schanz believes the condition one of inflammation of the tendon itself and due to overwork.

Treatment.—Put the foot in a position of slight plantar flexion. Apply a strap of adhesive plaster from a point near the toes, along the sole, over the heel, up over the calf, to near the knee. Keep the strap in position by a few circular strips of plaster and a bandage. Recovery ensues in two or three weeks.

BURSÆ.

In many places where tendons press upon bones or superficially situated bones are exposed to intermittent pressure the evil effects of the pressure are avoided by the interposition of synovial or mucous bursæ. Some of the bursæ are constant, *e. g.*, the prepatellar; others, *e. g.*, those over the malleoli, develop as a result of irritation. Some bursæ communicate with neighboring articulations; thus one located between the gastrocnemius and semimembranosus is continuous with the knee-joint in one-half the cases. Bursæ are subject to the same forms of inflammation as are tendon-sheaths.

Infective bursitis is common as the result of direct infection through a wound or from contiguous foci of disease; it may also arise by metastasis. Gonorrhea and rheumatism are frequent causes of bursitis. The symptoms are those of any localized inflammation.

Treatment.—If resolution seems possible, rest with the use of hot and cold applications is proper. If resolution is not probable or if pus is present, freely incise; scrape away all necrosed tissue, swab the wound with tincture of iodin, Harrington's solution, or with liquid carbolic acid, neutralizing the latter immediately by swabbing with alcohol, provide for drainage, and apply dressings.

Acute Simple or Non-infective Bursitis.—As the result of a severe blow hemorrhage and effusion into a bursa are common and give rise to acute simple or non-infective bursitis. This is particularly common in the prepatellar bursa. After a fall, *e. g.*, on the ice, there are pain and swelling over the knee, the swelling exactly simulating in appearance the familiar housemaid's knee. Ecchymosis is the rule. Under appropriate treatment recovery ensues within a few days.

Treatment.—(1) By gently rubbing with the fingers or thumb, coax away from the part as much of the effused fluid as possible; surround the part with a liberal cushion of cotton and apply a bandage. Elevate the affected limb and give rest.

(2) Instead of applying pressure by means of a bandage as above, the part may be strapped with adhesive plaster and the patient encouraged to walk. The strapping must *not* be applied tightly. When the part is at rest, the pressure of the strapping ought not to be felt, but when in motion, it ought to receive support from the strapping. In a very short time the strapping must be reapplied, as diminution in the swelling will render it loose. This ambulatory treatment has given me much satisfaction. If the effusion fails to become absorbed, it may be evacuated by aspiration or incision, but this will very rarely be necessary.

FIG. 335.—HOUSEMAID'S KNEE.

Chronic Simple or Non-infective Bursitis.—From the irritation of a badly fitting shoe there develops inflammation around and effusion into a bursa situated between the os calcis and the tendo Achillis; from constantly repeated traumata to the knees due to too much kneeling there develops a similar lesion of the prepatellar bursa (housemaid's knee) (Fig. 335). In the same manner tailors suffer from inflammation of a bursa over the external malleolus, due to their posture; miners who support themselves on their elbows while at work are liable to inflammation of the bursa over the olecranon (miners' elbow), while boatmen have a similar lesion over the ischial tuberosities. Probably the most common and annoying form of bursitis is that known as *bunion*. As the result of a badly fitting shoe the great toe is pushed toward the middle line of the foot, and the head of the first metacarpal becomes very prominent. A bursa forms under the skin, over the bony prominence. Inflammation of this bursa constitutes the bunion. The trouble is entirely secondary to the bony deformity (hallux valgus).

Pathologically, these lesions are identical with those of simple chronic tenosynovitis and require no special description. In certain situations, *e. g.*, in the retrocalcaneal bursa, exostoses may form in the walls of the bursa. The walls of the bursa are much thickened, and usually present rugosities. Villous protuberances into the cavity are common. Rice bodies may be present, but these belong more particularly to cases of tuberculosis.

Langemak[10] considers that bursæ are formed in exactly the same manner as are ganglia, and that a bursal hygroma (*e. g.*, housemaid's knee) is merely an exaggeration of the process which originally formed the bursa. Thus, according to Langemak, the lesion we have entitled chronic simple bursitis is not an inflammation, but a collagenous degeneration due to local hyperemia the result of repeated traumata. Many things seem to support Langemak's theory. Chronic bursitis is subject to acute or subacute exacerbations.

Tuberculous Bursitis.—Like tendon-sheaths, bursæ may be the site of tuberculosis. The pathologic anatomy of the two is identical. The disease may be grafted upon a chronic simple bursitis, hence many cases of apparently non-infective bursitis or hygroma are in reality tuberculous.

Symptoms of Chronic Bursitis.—According to the situation of the disease, pain may or may not be a prominent symptom. In chronic retrocalcaneal bursitis (*Albert's disease*), walking or dorsal flexion of the foot causes great pain, while in bursitis of the prepatellar bursa there is no pain unless an acute or subacute inflammation, usually the result of trauma, is grafted on the chronic.

The diagnosis is based on the presence of a limited swelling located at the site of a bursa; the swelling may be tense or soft; fluctuation is present, and if rice bodies are contained in the cyst, they may give a feeling of crepitation on palpation. If the bursa can be emptied of its contents by pressure, this means that it communicates either with a joint or with some other deep-seated bursa. As a rule, the diagnosis of chronic bursitis is easy, but the differentiation between chronic simple or non-infective and tuberculous bursitis is often impossible. This, however, is of no great importance, as the treatment of both is essentially the same.

Treatment.—The first principle of treatment is, of course, the removal of the cause. The active treatment may be conservative or operative. Conservative treatment consists in rest with pressure to the part, or in the use of adhesive strapping as recommended in acute bursitis. Operative treatment ought not to be too long delayed if conservative measures do not give early evidence of success. Delay is dangerous, because tuberculosis may be present.

Methods of Operation.—(1) Puncture. Evacuate the contents, scarify the interior. Apply pressure by means of adhesive strapping. Permit the patient to walk as much as desired. Hoffmann[28] found this treatment successful in almost every one of 104 cases.

(2) Evacuate the contents with a trocar. Inject iodoform-glycerin emulsion. This is specially useful in cases of large iliac bursæ.

(3) Incise, evacuate, curette, swab the walls with tincture of iodin, and provide drainage. If any exostoses are present, remove them.

(4) Excise the bursa and close the wound completely. Where feasible, this is the ideal operative treatment.

Tumors of Bursæ.—Tumors of bursæ are rare. Delfino[30] could only find reports of 31 cases. They are most common in the prepatellar bursa, but may be multiple. Duret found 5 bursæ simultaneously the site of endotheliomata. Sarcomata and myxomata are the commonest forms of tumor. They may arise in a previously healthy bursa as well as in one previously damaged. Bursal tumors, as a rule, grow comparatively slowly and are favorable for excision, which is the only proper treatment.

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CHAPTER XXVIII.

ORTHOPEDIC SURGERY.

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The word orthopedic, as defining a special department of surgery, was given to this specialty by Andry (1741), who derived the term from two Greek words, ὀρθός, "straight," and παῖς, "a child."

Orthopedic surgery is that department of surgery which deals with the prevention and cure of deformities. In the prevention of deformity the treatment of chronic diseases of the joints occupies no small place in American practice. German usage, as expressed in its modern text-books,[104] however, limits the specialty rather to the treatment of existing deformity.

Deformities are either congenital or acquired.

Congenital deformities are divided theoretically into primary and secondary. The primary ones are those in which there is some defect or anomaly in the embryo itself. Secondary congenital deformities are those due to intra-uterine trauma or disease, and to pathologic conditions of the amnion or deficiency of amniotic fluid. We really have very little definite knowledge of the subject—often not enough to enable us to say whether a given deformity, for example, a congenital dislocation of the hip, is the result of one cause or another, and whether it is to be classed as primary or secondary.

Acquired deformities are due to a multiplicity of causes, the most frequent of which are to be found in tuberculous disease of the joints, rickets, trauma, and anterior poliomyelitis.

POTT'S DISEASE.

Synonyms.—Spondylitis; malum Pottii; kyphosis; caries of the spine; hump-back; angular curvature of the spine; tuberculosis of the vertebræ. German, die Pott'sche Kyphose; Spitzbuckel; tuberculose Wirberlent-zündung. French, mal de Pott and mal Vertébral. Italian, gibbosita; curvatura angualore della collona; malle di Pott.

The name of Pott's disease is given to a tuberculous affection of the vertebræ attacking in most cases the vertebral bodies, rarely the laminæ and spinous processes. It is named from the English surgeon, Percival Pott, by whom it was first described in 1776.

Occurrence and Etiology.—The disease occurs more often in males than in females,—2045 males and 1750 females in 3797 cases,[1]—

and is in America one of the two most frequent locations of joint tuberculosis. At the Children's Hospital, Boston, in 5950 cases of joint tuberculosis in children 2867 were of the spine and 2281 of the hip.

Age.—It is primarily a disease of middle childhood, but may occur at any age. The relative frequency of occurrence at different ages is seen in the table:

Ages.	Mohr (72 Cases).	Drachman (161 Cases).	C. F. Taylor (375 Cases).
1– 5	20.0 per cent.	41.0 per cent.	60.3 per cent.
6–10	22.0 "	36.0 "	18.0 "
11–15	20.0 "	13.7 "	6.4 "
16–20	16.7 "	5.0 "	....
After 20	11.0 "	4.3 "	....

Location.—The location may be at any part of the column, but is most frequent near the dorsolumbar junction.

Location.	Dollinger (538 Cases).	Ruptured and Crippled Hospital (1355 Cases).
Cervical	63	100
Dorsal	321	854
Lumbar	154	317

The etiology of the affection is the same as that discussed in the section on joint tuberculosis in general.

Fig. 336.—Anatomic Specimen from Dorsolumbar Pott's Disease.

Fig. 337.—Retropharyngeal Abscess in Cervical Pott's Disease (Bradford and Lovett).

Pathology.—The pathologic changes consist of a tuberculous affection of the spongy tissue of one or more vertebral bodies, generally at the anterior portion, and more often near the articular cartilage than elsewhere. A superficial infection of the front of the vertebral column is recognized and spoken of as spondylitis superficialis.[2] The laminæ, spinous and transverse processes are rarely attacked, but their occasional invasion is recognized.

Inasmuch as the vertebral column is a weight-bearing structure, the softening of a vertebral body is apt to result in the collapse of the column as the result of the superincumbent weight, and the column falls forward above the point of the collapsed vertebra and forms a more or less sharp backward projection of one or more spinous processes at the seat of the disease, which is known as the *kyphus*. Two separate foci of infection occur rarely. The body weight pressing upon the diseased and softened vertebra gains a continually increased leverage, and the destruction and deformity are likely to extend.

FIG. 338.—GLUTEAL ABSCESS FROM POTT'S DISEASE.

FIG. 339.—PSOAS ABSCESS IN POTT'S DISEASE.

Repair comes about by the substitution of newly formed bone for the tuberculous tissue, and the gradual formation of ankylosis at the seat of the disease. When the upper part of the column falls forward, it naturally carries with it the ribs and the sternum, and deformity of the chest and prominence of the sternum are accompaniments of the deformity in severe cases, the lower ribs in the most marked cases coming below the crest of the ilium. The distortion of the aorta and a change in the relation of the viscera of the thorax and abdomen are necessarily caused by the change in the shape of the chest.

Abscess.—The products of the softening caused by the tuberculous processes often find their way out under the vertebral fascia into the

Fig. 340.—Lumbar Abscess.

Fig. 341.—Torticollis from Cervical Pott's Disease.

Fig. 342.—Stoop of Healthy Child (Moore).

Fig. 343.—Showing Stoop of Pott's Disease (Moore).

surrounding structures. In the cervical region they accumulate back of the pharynx, forming a retropharyngeal abscess; in the dorsal region, they occur most often in the mediastinum, or passing between the ribs, rarely appear in the back as dorsal abscess; in the lower dorsal or lumbar region they follow down the course of the psoas muscle, to appear in the groin as psoas abscess, or they turn around the erector spinæ and quadratus lumborum muscles and appear in the loin as lumbar abscesses.

Paralysis.—The meninges of the cord may become involved by extension of wide-spread disease, particularly disease extending to the posterior part of the vertebral bodies. Their inflammation results in thickening and possibly pressure on the cord at the seat of the inflammation. Embolism of the spinal vessels must be mentioned as another

FIG. 344.—CERVICAL DORSAL POTT'S DISEASE.

FIG. 345.—CERVICAL POTT'S DISEASE.

cause of the disturbance. Direct strangulation of the cord by the bone of the vertebral arch or by loosened pieces of bone may be also a cause of paralysis. The presence of an abscess on the cord must also be remembered as an occasional source of pressure. If meningomyelitis is present and subsides, it leaves behind it a certain amount of sclerosis, from which may follow both descending and ascending degeneration.

Symptoms.—**Early Symptoms.**—Besides the symptoms of fatigue, loss of flesh, and impairment of the general health, such children begin to support themselves, when tired, by tables and chairs, they walk stiffly, and are subject to paroxysmal abdominal pain.

Attitude.—Peculiarity of attitude and gait is early noticed; the patient walks with the spine held stiffly and with great care to avoid jar, the feet being placed carefully upon the ground with most of the weight borne upon the toes. Such patients rise from a chair with the spine held stiffly, and in all movements unconsciously protect the spine by contracting the muscles controlling it. In disease of the lower half of the column, in stooping to pick up anything, the spine is not flexed as is normally done, but the hips and knees are bent, lowering the pelvis, while the spine is held rigid.

The attitude varies according to the region of the spine affected. In

Fig. 346.—Lordosis in Lumbar Pott's Disease.

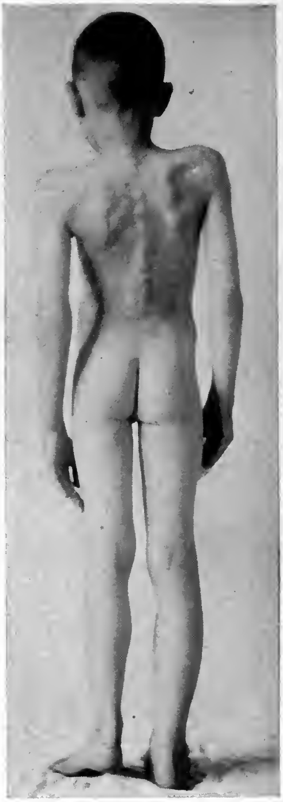

Fig. 347.—Lateral Curvature from Lower Dorsal Pott's Disease.

cervical Pott's disease wry-neck is a common distortion, or the head may fall forward on the chest or be sharply hyperextended. In cervical disease the lower spine is generally straightened and the lumbar curve diminished—sometimes so much so as to suggest a second focus of disease. In middorsal disease the shoulders are held high and a characteristic appearance of abnormally square shoulders is given. In lumbar disease the patient leans backward from the waist in an attempt to throw the weight off of the diseased bodies (Fig. 346).

Lateral deviation (Fig. 347) in all regions of the spine is a common accompaniment of Pott's disease.

Pain.—This symptom is rarely absent, and is generally referred to the peripheral ends of the nerves involved. In the cervical region occipital neuralgia is noted; in the dorsal and lumbar regions the pain is in the chest and abdomen. The later symptom of abdominal pain is one of the most frequent in Pott's disease, and is the most frequent cause of a mistake in diagnosis. Some pain is likely to be felt in the

FIG. 348.—DORSOLUMBAR POTT'S DISEASE.

FIG. 349.—LOWER DORSAL POTT'S DISEASE (Bradford and Lovett).

back, and it is particularly severe in the rare cases where the laminæ are affected; the name "apophysalgie Pottique" has been given to this condition.[3] The pain is increased by jars and accidents and is, as a rule, more severe than in any form of joint tuberculosis. Analogous to the pain described are the occasional symptoms found in the eye, consisting of a dilatation of the pupil, neuritis, and optic atrophy. In the cervical region grunting respiration, cough, and dyspnea may be found. In cases with excessive deformity severe paroxysmal pain may be caused by the slipping of the ribs on the crest of the ilium.

Deformity.—The most characteristic symptom of Pott's disease is the deformity caused by the collapse of the vertebræ, resulting in a backward prominence of the spinous processes. In the acute stage of the disease this deformity is generally sharp and angular, but in the later stages tends to become rounded. The deformity is most conspicuous in the dorsal region, on account of the normal backward convexity of the spine at that point, and it is least noticeable in the lumbar and cervical regions on account of the forward curves at these points. The loss of height noticed in such patients, especially when the disease is of long standing, is due not only to the actual destruction in the bone and the shortening of the column, but to a general retardation of growth.

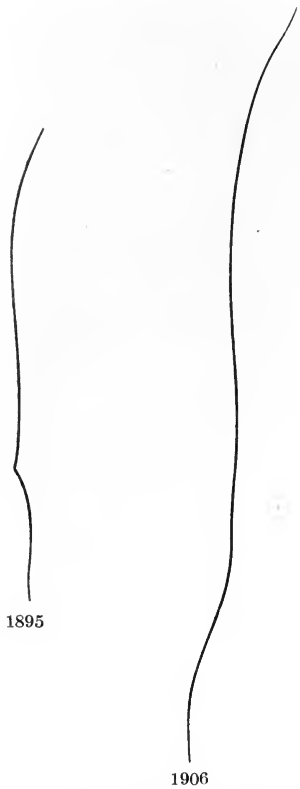

Fig. 350.—Tracing of Spine.

It is most important that in all cases a record of the deformity should be kept, which can be done by taking a tracing over the spinous processes with a lead tape and drawing the outline on a piece of cardboard, which is then cut out and fitted to the spine to secure greater accuracy, while the patient lies on the face. The deformity of the chest is usually the thrusting downward and forward of the sternum, with lateral flattening of the chest. There may, however, be a prominence of the ribs on both sides of the sternum, which is apparently depressed.

High temperature is, as a rule, to be found in cases in the acute stage of Pott's disease with ambulatory treatment.

Abscesses are not usually accompanied by leukocytosis or rise in temperature. Their customary location has been described in the pathology. The symptoms of cervical abscess are difficulty in swallowing and respiration or the appearance, at the side of the neck, of a deep cervical abscess. Abscesses in the posterior mediastinum are accompanied by difficulty in breathing and cyanosis of an alarming character. Psoas or lumbar abscess first causes a limitation of the hyperextension of the leg on the affected side. This loss of hyperextension soon becomes a position of permanent flexion, and after the earliest stage a resistant mass is to be felt in the iliac fossa, and, rarely, the abscess appears as a fluctuating swelling in the buttock. Abscesses connected with any part of the spine may burst internally into the mouth, trachea, bronchi, esophagus, pleura, intestines, bladder, and rectum. Abscesses are most frequent in disease of the lumbar region, and least frequent in cervical disease.

Paralysis.—This may be one of the earliest symptoms noted and may be general or incomplete, but affects both legs. In extensive cases situated high up the arms may also be involved. The paralysis is at first motor in character, but later may become sensory and involve the sphincters. Early symptoms are weakness in the legs, increased reflexes at the knee, except in disease of the lumbar region, where the reflexes are diminished or absent. Loss of power quickly follows, and in the severer cases, paralysis of sensation and incontinence of urine and feces. The course of the complication is slow both in its onset and its recovery, and its recurrence is frequent. The dorsal region is the most frequently affected.

Fig. 351.—Psoas Contraction in Pott's Disease (Bradford and Lovett).

Diagnosis.—For a proper examination the patient, if a child, should be stripped naked; if an adult, the entire back should be exposed. Examination should be made on a table or the floor and not on a soft bed.

The patient should first be observed in his natural motions in getting up and sitting down, stooping, and turning the head, stiffness in motion being a significant symptom. The most common symptom relating to disease in the lower two-thirds of the column is to be observed by having the patient lie on his face and passively hyperextending the spine by lifting the legs from the table; if the region involved is the one affected by this motion, the muscles will stand out like stiff cords and check the hyperextension. In cervical disease the motions of the head should be carefully observed, as any restriction of them is suspicious. The existence of backward deformity in any region of the spine establishes the presence of a destructive disease of the vertebræ, most frequently, of course, Pott's disease. A rise of temperature at night, the presence of abscess in a characteristic situation, and the existence of a motor paralysis affecting the parts below the disease, with increased reflexes, all tend to establish the diagnosis. An x-ray photograph is of value in more or less advanced cases, by showing destruction of part of the body of the vertebra. In early cases a negative x-ray cannot be accepted as establishing the absence of the disease.

Differential Diagnosis.—Cervical disease is most apt to be mistaken for congenital torticollis, rheumatic affections, sprains of the neck, and the position sometimes caused by inflamed cervical lymph nodes. Disease of the dorsal region is at times confused with round shoulders.

In the lumbar and lower dorsal regions the affections to be differentiated are rickets, and occasionally inflammatory affections of the abdomen which rarely may present stiffness of the spine and symptoms closely resembling Pott's disease.

Inflammation of abdominal lymph nodes[4] must at times be excluded by recognizing their presence by palpation of the abdomen and by the atypical and mild spinal symptoms.

The typhoid spine simulates Pott's disease most closely, but occurs late in typhoid fever, and presents generally symptoms of much severity, great prominence being given to the pain and nervous disturbance, and the differentiation between the two affections cannot be made by the symptoms. The presence of a Widal reaction may be of value.

Fig. 352.—Advanced Pott's Disease.

Malignant disease of the spine in the same way presents symptoms almost identical with Pott's disease. An x-ray in this case is likely to aid the diagnosis. Spondylitis deformans, or arthritis deformans of the spine, may at times resemble Pott's disease by its stiffness, pain, and rigidity, but the stiffness is more general, an angular kyphosis absent, and a good x-ray would be likely to show changes characteristic of bony deposit. The neurasthenic spine sometimes presents marked resemblance to Pott's disease, and frequently a sound diagnosis can be made only after several examinations and a careful study of the case.

Other affections resembling Pott's disease, and to be differentiated with care, are osteomyelitis, lateral curvature, which is fully described in the proper place, and the rare conditions of syphilis, aneurism ot the aorta, actinomycosis of the spine, spondylolisthesis, and the affection described as "arthropathies" of the vertebral column, any one of which may be accompanied by spinal deformity. Attributing the pain caused by Pott's disease to mythical "growing pains" is one of the most frequent causes of overlooking the disease.

FIG. 353.—TESTING FOR PSOAS CONTRACTION (Moore).

Prognosis.—Pott's disease in any region is always a formidable affection. The outlook is most favorable in the cervical and least favorable in the dorsal region. In general the elements which would establish a favorable prognosis are a good inheritance, fair general condition, early treatment, the absence of tuberculous disease of the other joints, and

FIG. 354.—SHOWING RIGIDITY OF SPINE (Moore).

the absence of fever and excessive pain at the onset. The unfavorable elements are naturally the reverse of these. Paralysis probably has no effect, either favorable or unfavorable, on the prognosis. Mortality statistics are apparently not of value, but the mortality is probably not under 33 per cent. if ultimate results are considered. Such an opinion, of course, is largely derived from hospital practice.

The prognosis of the deformity is far more favorable under modern methods than it used to be; without treatment it tends to increase, but under the best conditions of modern treatment it should be expected to remain stationary, and in favorable cases to improve. The prognosis of cases with abscess is less favorable than in cases without them, for the reason that abscess is an accompaniment of the severer cases and that, if the abscess becomes infected through operation or by breaking, a pyogenic infection is added to the tuberculous. In 49 cases of psoas abscess operated on at the Children's Hospital, Boston,[5] in the decade

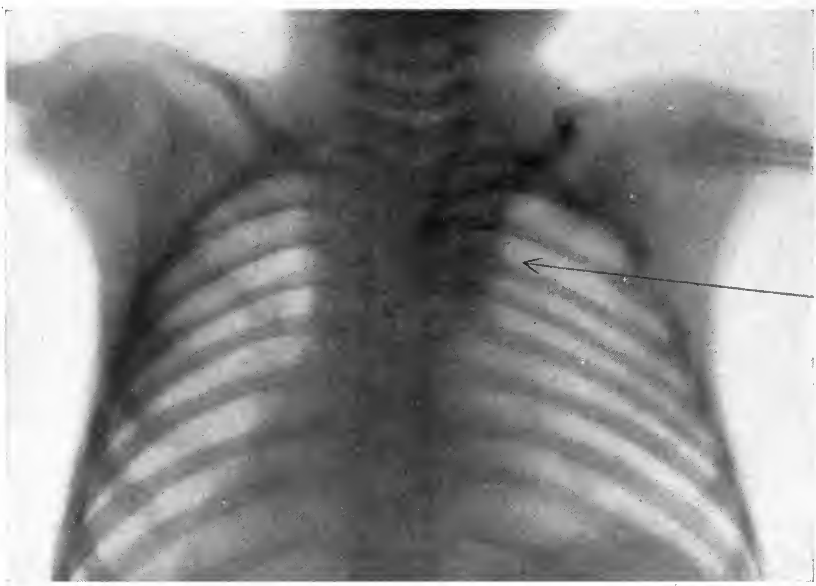

Fig. 355.—Upper Dorsal Caries.
Tuberculosis with mediastinal abscess; subsequent operation and recovery.

ending in 1900, 50 per cent. of the cases operated on in the first half of the decade were known to be dead and 26 of the cases operated on in the last half of the decade.

The prognosis of the paralysis itself is favorable. In 59 cases of paralysis[6] occurring in 445 cases of Pott's disease 39 wholly recovered, 3 recovered in part, 5 died of intercurrent affections, and in 12 the termination was unknown; thus in the whole number where the termination was known 83 per cent. recovered wholly. The occurrence of sensory paralysis and involvement of the bladder and rectum makes the prognosis less favorable, but even in these cases recovery may occur. The continuance of the paralysis unimproved for a year is to be counted as a somewhat unfavorable symptom.

Deaths from Pott's disease, when they occur, are generally due to tuberculous meningitis, sepsis, or amyloid disease of the viscera.

The length of time to be consumed in the treatment cannot be definitely stated, but it is, of course, likely to extend over several years.

Treatment.—Treatment is to be considered under the headings of general and local treatment.

General Treatment.—Under general treatment it is obvious that, as in the case of tuberculosis elsewhere, the hygiene should be the best available, sufficient food and fresh air having taken the place of drugs in the modern treatment. Activity should be restricted until the

FIG. 356.—TUBERCULOUS CARIES OF THIRD AND FOURTH LUMBAR VERTEBRÆ. Body of third pushed out to the side. Transverse process of fifth much larger on left, and touches the iliac crest.

stage of convalescence. Such children should lie down for part of the time, as it should be remembered that no apparatus is wholly efficient mechanically and that traumatism of the spine must be reduced to the minimum.

The outdoor treatment of tuberculous joints has assumed a prominence which is of great importance, and nowhere more strikingly than in Pott's disease. Such patients, even in a northern climate, should sleep practically out-of-doors the year round, with such protection as may be necessary in the way of warm clothes and sufficient bedding.

Local Treatment.—The problem of local treatment is to hold the spinal column in an improved position, to fix the vertebræ near the seat of the disease as nearly as possible, and to promote the formation of ankylosis, the two principles of treatment being fixation and diminution of superincumbent weight.

Bed Treatment.—Treatment by recumbency is necessitated when the disease is very acute, when the general condition is not satisfactory under ambulatory treatment, when paralysis is threatened or present, and when lateral curvature of the spine is a prominent symptom. It is necessary when the patient should lie upon a rectangular bed-frame, offering a resistant surface and pressing the deformity somewhat upward at the seat of the disease. A rectangular frame made of gas-pipe meets these indications. The frame should be about four inches longer than the patient, and the width of the frame should correspond to the distance between the axillary lines; it is covered by stout cotton cloth doubled, which can be laced down the back by a cord. A hole can be cut in the cover, under the buttocks, to allow the use of a bed-pan, or the cover may be made in two parts, leaving an open space under the buttocks. The patient is fastened to the frame by straps like those of a knapsack over the chest, and by a towel bound round the pelvis (Fig. 359). Under the deformity on each side are placed folded pillow-cases or sheets of sufficient height to press the deformity somewhat upward. The patient should lie on this frame continuously, being turned once a day to have the back bathed with alcohol and powdered, and to have the crumbs brushed from the surface of the cloth.

FIG. 357.—POSTMORTEM SPECIMEN OF DORSAL CARIES.

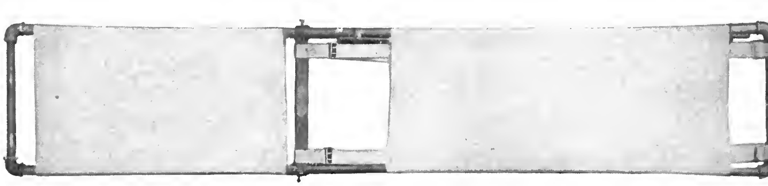

FIG. 358.—GAS-PIPE FRAME (Bradford and Lovett).

In disease of the cervical region head traction of one or more pounds should be added to the treatment by the bed-frame and the top of the bed raised. In cases of paralysis, in addition to the head traction, traction upon both legs sometimes hastens the recovery from the complication.

If contraction due to psoas abscess is present, traction should be made upon the leg, which is lifted to the position of deformity, and it should be gradually lowered to the normal position as the irritation subsides.

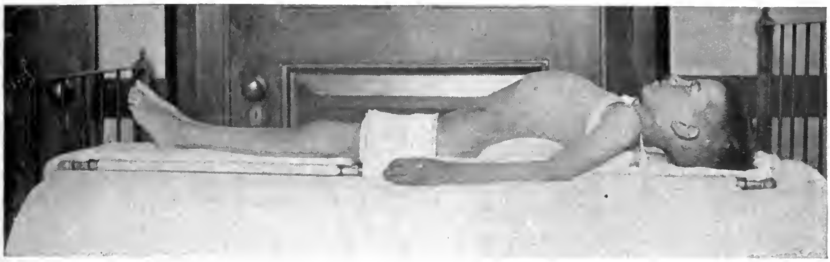

Fig. 359.—Bed Treatment in Pott's Disease.

Ambulatory Treatment.—Treatment while the patient is moving about has the advantage of enabling the patient to get into fresh air and of placing him in more normal surroundings. It is inferior in efficiency to recumbency during the acute stages.

Ambulatory treatment is carried out by jackets and braces.

Fig. 360.—Head Traction and Plaster Bed for Pott's Disease.

Treatment by Jackets.—In the acute stage of Pott's disease the treatment by jackets is in general the most available and easily carried out. In the convalescent stage of the disease treatment by braces is preferable.

The application of plaster jackets consists in winding around the patient (who is placed in an improved position so far as the deformity is concerned) wet plaster bandages which, on drying, hold the spine in a position of diminished deformity if the jacket is properly applied. It is important that bony prominences should be padded, that the jackets should not be too heavy, and that they should reach from as low down on the patient to a point as high up as practicable. Jackets should be renewed as infrequently as possible, being left on six months or a year when they are efficient and comfortable.[7]

Application of the Jackets, Lying on the Face.—The patient should lie face downward on a hammock of stout cloth, not quite as wide as the thorax. The cloth is fastened to a rectangular frame of gas-pipe at one end firmly, and at the other by means of a rod attached to the other end of the frame fastened to a screw and chain, by which means the hammock can be made either tight or loose. The bony prominences are padded, and felt pads should be placed at the sides of the deformity of at least an inch in thickness. The jacket is then applied as far as the level of the apex of the deformity and allowed to harden. The hammock is then loosened, hyperextending the patient and straightening the upper part of the spine. This is carried to the point of slight discomfort and the jacket completed. In this way a hyperextension is obtained directly at the seat of disease.

Fig. 361.—Plaster Jacket (Bradford and Lovett).

Another method[8] of applying jackets on the face will be found in the reference.

Jackets Applied with Patient Lying on the Back.—Jackets may also be applied with the patient recumbent on the back, in which case the patient lies either upon two rods bent to secure the necessary hyperextension, these rods being fastened to the frame by means of a supporting apparatus, or a simple rest is placed under the apex of the deformity and another rest under the buttocks; by this means the weight of the body acts to hyperextend the deformity at the seat of the disease.[9] After the completion of the jacket the rods are withdrawn from under the jacket.

Jackets Applied During Suspension.—The original method of applying plaster jackets with suspension, with the patients standing, has practically been superseded by the more modern methods, which are more efficient. The simple suspension affects chiefly the physiologic and compensatory curves and has comparatively little effect on the kyphus. The suspension method can, however, be utilized if one adds to it forward pressure at the seat of deformity, which has been applied by R. T. Taylor[10] by an instrument called the *kyphotone.* In this case the patient sits, and while strong traction is made upon the head, a forward pressure, by means of a horizontal screw carrying a pad, is made upon the kyphus. A similar method has been employed by Wullstein.[11]

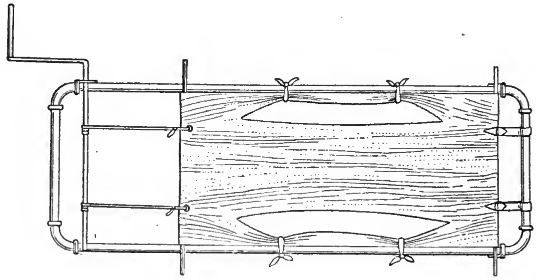

FIG. 362.—HAMMOCK FRAME FOR THE APPLICATION OF JACKETS DURING RECUMBENCY ON THE FACE. Ready for use (Bradford and Lovett).

For cases in the acute stage of Pott's disease a solid jacket is desirable. In convalescent cases, or if for any reason it is necessary to remove the jacket and inspect or treat the skin of the back, the jacket may be split down the front and fastened with lacings. As a substitute for such removable plaster jackets corsets may be made of leather, felt, wood, aluminum, celluloid, papier-mâché, etc. Such jackets are made on a cast which is secured by applying a plaster jacket in one of the ways described, splitting it, and removing it, filling the empty jacket with plaster-of-Paris and water, and applying over this cast the leather or other material which it is desired to use for a permanent jacket.

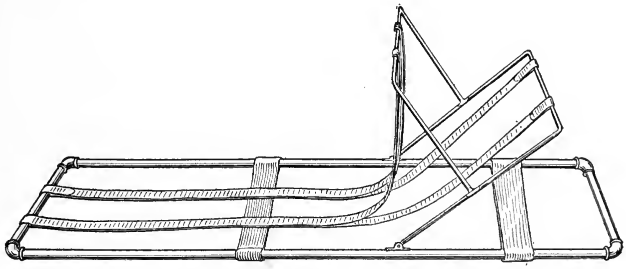

FIG. 363.—FRAME WITH MOVABLE SECTION FOR APPLICATION OF PLASTER JACKETS (Bradford and Lovett).

Treatment by Braces.—Although in competent hands the treatment by braces must be regarded as highly efficient, it requires in all cases accurate knowledge of the mechanic problem to be met, and familiarity on the part of the surgeon with the fitting of apparatus. The two most efficient braces for the treatment of Pott's disease are the anteroposterior steel support devised by C. F. Taylor and the brace of Dollinger.[12]

The Taylor apparatus consists of two uprights of annealed steel, fitted to the curve of the back to make pressure forward at the seat of deformity. The uprights are joined by an inverted U-shaped piece of steel which runs down nearly to the sacrum; at the top the uprights end in a shallow, U-shaped piece of steel the free ends of which terminate on the anterior border of the trapezius at a point half-way between the root of the neck and the end of the clavicle. Accurately fitted pad plates are placed between the braces and the back at the point of deformity. The brace is held to the patient by means of an apron of cloth or leather covering the anterior part of the body from the top of the sternum to the lower part of the abdomen. To hold the upper part of the body from falling forward a chest-piece is desirable. The brace should be worn day and night, being removed daily in order that the back may be bathed. Under no circumstances should the patient sit erect when the brace is not applied.

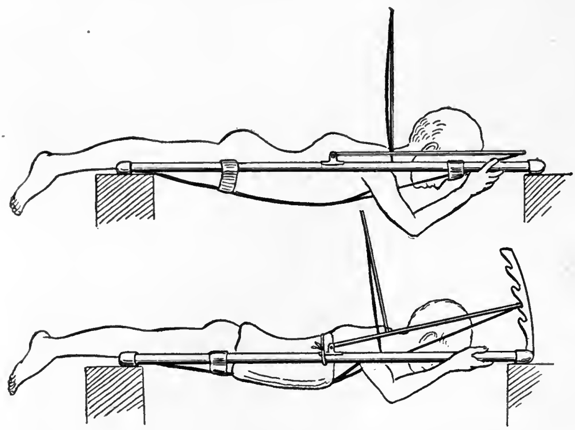

Fig. 364.—Frame with Movable Piece in Use (Bradford and Lovett).

The brace of Dollinger is more elaborate and consists of a steel frame for the front and back of the patient, which is strapped together at the sides. It contributes better fixation than the Taylor brace, but is heavier and more difficult to fit.

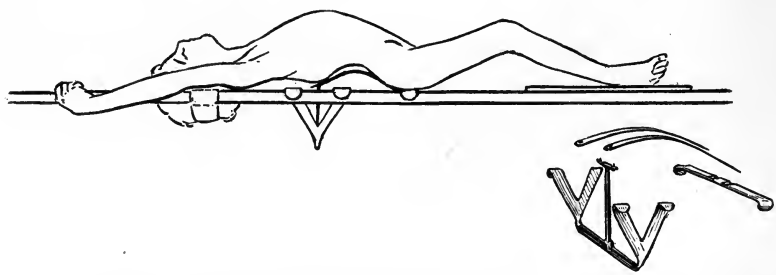

Fig. 365.—Frame for Application of Jacket with Patient Placed upon the Back (Metzger and Goldthwait).

The principle of the Taylor brace consists in applying leverage forward upon the point of deformity.

Head Supports.—In disease above the middle dorsal region no brace can be considered efficient which does not obtain some hold upon the head.

In disease of the upper cervical region the Thomas collar can be regarded as an efficient apparatus. This consists of a leather stock or roll which encircles the neck. The most universally useful head support is an oval ring attached to the upper part of the Taylor brace by a post running from its upper part. This post can be lowered and raised as is necessary and can be arranged to allow motion in a horizontal plane if desired.

When it is desired to use a head support in connection with jackets, an upright may be run up from the back of the jacket, carrying the chin support. The jury-mast, formerly used in connection with plaster jackets,

Fig. 366.—Anteroposterior Back Brace (Bradford and Lovett).

Fig. 367.—Side View of Anteroposterior Brace.

consists of an upright piece of steel running above the head, from which the head was slung by means of a leather Sayre head support. The unsightliness of this method has led to its discontinuance in favor of the less disfiguring apparatus described.

Forcible Correction.—It has been demonstrated in acute Pott's disease that if sufficient corrective force is used, the deformity of the spine can be obliterated or very much diminished. The method practised by Hippocrates and Paré was revived by Chipault[29] in 1895, who added to the correction of the deformity a wiring together of the spinous processes, a proceeding originally proposed to the American Orthopedic Association by Hadra in 1891. This method without the wiring was subsequently advocated and popularized by Calot,[30] with whose name it has been generally associated. The method advocated was by traction on the head and feet while the anesthetized patient lay prone on a roll under the pelvis and one under the chest. Downward pressure was then exerted on the kyphus of from 30 to 80 pounds, and the deformity diminished or obliterated. A plaster-of-Paris jacket was then applied in the corrected position and worn from six to eight months. In spite of the claims of its early advocates and the very extensive use of the operation a few years ago, it has not been followed by the permanent success hoped for it, and today in its original form has fallen into discredit, but has served a most useful purpose in showing that mild degrees of corrective force, as described above in speaking of plaster jackets, might be used with benefit and safety. The operation of forcible correction is attended by risk to life, as shown by 610 cases collected from 29 operators:[13] there were 21 deaths following operation, due to the following causes:

FIG. 368.—FRONT VIEW OF BRACE FOR CERVICAL POTT'S DISEASE.

Meningitis	5
General tuberculosis	4
Trauma of operation	4
Intercurrent disease	3
Not stated	5
	21

Other accidents reported have been paralysis, rupture of abscesses, rupture of the pleura, and exacerbation of the process. The operation is not consistent with what we know of the pathology of the disease. Inasmuch as the hope of a cure rests upon the ankylosis at the seat of disease, the forcible tearing apart of the cicatrizing surfaces is not only calculated to retard the process of healing and cause an aggravation of the acute process, but it leaves a gap between the separate vertebræ which it has not yet been demonstrated will be filled by supporting bone. On the whole, the permanent results of the operation have not been satisfactory. The use of anything more than a mild degree of force is at present confined to the treatment of paralysis, where, in certain cases, the application of a moderate degree of force has resulted in an immediate improvement of paralytic symptoms. For this proceeding anesthesia is not necessary.

Treatment of Abscess.—*Treatment by Expectancy.*—The best treatment of abscess is its absorption. To obtain this the patient is placed under the most favorable conditions with regard to local and general measures and activity is restricted.

Treatment by Aspiration.—The simple aspiration of a tuberculous abscess is likely to be followed by its refilling afterward, and repeated aspiration is, of course, attended by the risk of sepsis. The treatment of aspiration, followed by the injection of germicidal solutions, such as formalin, camphor, naphtha, iodoform, and the like, is attended by risk of poisoning in the case of iodoform, *e. g.*, but is claimed to be effective in causing the disappearance of the abscess.[14] The abscess is emptied by a puncture of the canula through the sound skin, and 30 to 100 grams of a 10 per cent. emulsion of iodoform in glycerin or olive-oil is injected. The abscess will refill rapidly, and from three to four punctures will be necessary in the course of the next month or two. A 1 to 5 per cent. solution of formalin is also advocated.

Treatment by Incision.—The incision of tuberculous abscess is delayed as long as possible for two reasons: it is impossible thoroughly to clean out the tuberculous tissue by any operation, however extensive; and the drainage of such abscesses results ultimately in pyogenic infection, which is an undesirable addition to the tuberculous process. When, however, abscesses fail to absorb, or refill repeatedly after aspiration, when they threaten to break or are acute in character, incision is necessary. Under these circumstances the abscess should be incised, thoroughly wiped out and washed out, and drained. If a free incision is made, it is not always necessary to insert a wick, and in some cases if this is not done, the abscess will close practically by first intention, the size of the wound being sufficient to permit drainage. Dressings should be as infrequent as possible, and should be done with the utmost care with regard to preserving asepsis as long as possible.

The sewing up of tuberculous abscess after operation is at times successful in securing union by first intention, but subsequent breaking down occurs in the majority of cases. For such a proceeding the abscess wall must be scrubbed free of pyogenic membrane by gauze and thoroughly dried before being sewed up.[31]

Treatment of Paralysis.—When paralysis is threatened, the patient should be treated by recumbency with traction. When paralysis is present, a jacket should be applied (in which one may use more corrective force than would be justifiable or desirable under other circumstances), and the patient treated by recumbency for some weeks at least. The use of the cautery, counterirritants, and drugs is to be condemned.[6]

Unusually efficient and careful treatment should be continued for at least one year, and, as a rule, for a much longer period. If a radiograph should show the presence of an abscess at the seat of the deformity in a case of paralysis, aspiration or incision of that abscess should be performed.

Operative Treatment of Paralysis.—The operation consists in laminectomy at the site of the disease, with or without opening of the dura. It is important that a probe be passed up and down the spinal column to be sure that pressure on the cord does not exist above and below the opening at the site of the disease. Laminectomy is an operation which is not gaining favor; the death-rate is high (over 50 per cent.), and although brilliant success at times follows the operation, it should be performed only in cases where there is very good reason to believe that recovery will not occur under the ordinary treatment described.[32]

Operations upon the Diseased Vertebræ.—Experience has shown that it is not good surgery to attempt to cut down on the diseased vertebræ to remove the tuberculous portions unless the operation is forced on one by circumstances. Such circumstances are—(1) When there is reason to suspect a deep-seated abscess of importance; (2) when it is necessary to open an existing abscess; (3) when a large sequestrum is present; (4) when it is necessary to secure drainage in order to avert sepsis. Under these circumstances the site of the disease may be explored and diseased bone removed with benefit. If a sequestrum is found, it is clearly to be removed, but extensive traumatism with a curette is not advisable whether a sequestrum is present or not. Loose and necrotic bone is to be scraped away, but a consideration of the pathologic process will show us that such operations must necessarily be incomplete and cannot reach all the affected bone; with this limitation clearly recognized it is evident that traumatism extensive enough to expose sound bone in all parts is not warranted, even if such bone were wholly accessible, and that operations upon the vertebræ must be regarded as palliative rather than radically curative.

When the site of the incision is not determined by the location of the abscess, the vertebræ are accessible in the separate regions as follows: The cervical vertebræ are to be reached through the back of the pharynx or preferably at the side of the neck. The former incision is permissible only when a retropharyngeal abscess is on the point of breaking into the pharynx on account of the ready infection of the opening by the bacteria of the mouth. The incision to be recommended is made along the posterior border of the sternomastoid muscle, the sternomastoid and omohyoid are raised, and the space made by the splenius and omohyoid is reached. The dissection is carried through the longus colli and the vertebral arteries avoided.

The bodies of the dorsal region are reached by an incision at the side of the spinous processes, uncovering the tops of the transverse processes and the bases of the ribs; the ribs are divided at the tuberosities, and after the soft parts have been freed by a blunt dissector, the transverse processes and base of the ribs are removed over the affected area.

The lumbar bodies are to be exposed by an incision reaching from the twelfth rib to the ilium, at the border of the quadratus lumborum, and the tips of the transverse processes should be felt. The dissection should be carried down to the psoas muscle, some fibers of which should be detached from one transverse process, and the finger can strip up the psoas muscle and reach the vertebral bodies.

After the removal of the diseased bone the wound is to be lightly packed with iodoform gauze, or drained by a tube, and the mechanic treatment of the disease carried on as before. Confinement to bed is necessary only for a few days, so far as the operation is concerned.

LATERAL CURVATURE OF THE SPINE.

Synonyms.—Scoliosis; rotary lateral curvature. German, Skoliose; seitliche Rückgratsverkrummung; Kypho-skoliose. French, scoliose; déviation latérale de la taille. Italian, scoliose.

The term lateral curvature, or, more briefly, scoliosis, is applied to any constant deviation of the spine or any part of it from its normal position in the median or sagittal plane of the body.

Occurrence.—Scoliosis is either congenital[235] or acquired. Scoliosis of congenital origin is more frequent than was formerly supposed, since the use of the *x*-ray has shown the frequent presence of congenital anomalies of the vertebral column.

Statistics would show it to be an exceedingly frequent affection. In 2314 school-children investigated in Lausanne, scoliosis of some degree was present in 24.6 per cent. Practically the same percentage holds where other large groups of children have been investigated.[237]

Sex.—Although boys and girls are found to be affected with about the same frequency when any large group of school-children are investigated (Lausanne series: boys, 23 per cent.; girls, 26.7 per cent.), when an analysis of cases coming for treatment is made, the girls predominate in the proportion of about five or six females to one male. Yet the severest forms of scoliosis are to be met in males.

Fig. 369.—Right Dorsal Scoliosis (Warren Museum).

Age.—The affection most frequently occurs in the second half of the first decennium. It does not, as a rule, begin at puberty, as commonly supposed. Eulenberg, in 1000 cases, found 564 developing between the ages of seven and ten.

Pathology.—The changes occurring in scoliosis are most striking in the spine, and may vary from moderate asymmetry to extreme distortion. In general the spine is curved to one side in some part of its length, or it is curved in one direction in one part, and in the opposite direction above or below. In addition to the lateral curve, the curved region is rotated or twisted on a vertical axis through a considerable arc, the bodies of the vertebræ always turning toward the convex side of the lateral curve. This association of twist and side bend is constant, although in some cases the rotation is out of proportion to the lateral curve, and in other cases the lateral curve predominates over the rotation.

In addition to the side curve, alteration in the normal, anteroposterior curves are found, consisting chiefly of an increased or diminished dorsal convexity. The relation of these changes to the lateral curve is but little understood. The changes which have brought about this alteration in the shape of the column are not the result of destructive disease, as in Pott's disease, but rather of bone yielding to static causes and abnormally distributed pressure. Such changes reach their maximum at the point of greatest curve, the individual vertebræ becoming wedge-shaped at the apex of the curve, while above and below the apex they become lozenge-shaped.

FIG. 370.—SCOLIOSIS DEXTROCONVEXA KYPHOTICA (after Riedinger).

The vertebræ are not, however, compressed directly on one side, but are thinnest in the case of the dorsal region at the back of the concave side of the curve. Such vertebræ taken by themselves are no longer symmetric. They are distorted in the dorsal region as if one took a plastic vertebra in the hands and bent the part behind the body toward the concave side of the lateral curve. The intervertebral disks are first flattened on the concave side of the lateral curve, and finally atrophied under pressure. The ligaments at the side of the vertebræ become shortened on one side and stretched on the other. The muscles are found stretched, atrophied, thin, and fatty in severe cases on the side of the convexity of the curve, and shortened on the concave side without marked degenerative changes.

FIG. 371. — DISTORTED SAGITTAL PLANE OF A SCOLIOTIC VERTEBRA (Riedinger).

Such changes in the spine must, of course, be accompanied by distortion of the thorax and pelvis. The changes in the soft parts are of practical importance. Intercostal nerves are likely to be compressed and irritated in severe cases, giving rise to symptoms of thoracic and abdominal pain, but the most important changes are in the lungs. The lung of the right side is compressed, and most of the breathing is done by the other. Mosse found apex infiltration in 60.2 per cent. of 100 scoliotic children between five and sixteen years old.[242] V. Cade found apex "affections" in 73 per cent. of scoliotic women, the lung affection being predominantly of the lung on the convex side of the curve. The heart shows muscular hypertrophy and dilatation of the right heart in a large proportion of severe cases (56.4 per cent., Bachmann), while the left heart is less frequently affected in a similar manner (17.5 per cent.). The abdominal organs are displaced and distorted in severe cases, the liver, especially in right curves, showing compression of its right side, with perhaps indentations from rib pressure on its surface, and expansion of its left side. The stomach is also at times displaced and compressed, and similar alterations of less importance are found in the other viscera.[244]

The changes found in destructive bone disease which occasionally may cause atypical lateral deviation of the spine are not described here, but under the separate headings dealing with those diseases. Malformations of the spine and ribs cause lateral curvature at times and are not especially described in the above consideration.


Fig. 372.—Left Total Curve.

Etiology.—So long as bone was regarded as a fixed and unalterable structure, the pathologic appearances in lateral curvature were not understood, but since it has been learned that bone is adaptive and that its growth and structure are influenced by pressure, it becomes evident that the changes just described are those induced by growth of the spine in a distorted or curved position, or in a less degree by the maintenance of a distorted position in persons who have reached their growth.

The affection occurs occasionally in quadrupeds.[247] It has been produced experimentally by Wullstein [248] in young dogs who were kept for some weeks in bandages causing a curved position of the spine. Arnd[249] produced experimental scoliosis in rabbits by division of the erector spinæ muscles on one side.

Causes.—Remote causes need not be sought to account for scoliosis: given an asymmetric position of the spine from any cause, the mechanism is at hand to produce in certain cases any degree of deformity; in other cases the deformity will remain stationary and not progress beyond a mild degree.

The causes most commonly found are as follows:

1. Faulty attitude in sitting and standing, favored by improper school furniture. 2. Occupations or recreations necessitating the prolonged maintenance of a one-sided position. 3. Inequality in the length of the

limbs tilting the pelvis and asymmetry of the pelvis. 4. Unequal vision or hearing on the two sides, causing a twisted or bent position of the head. 5. Paralysis of the muscles of the back (anterior poliomyelitis, cerebral paralysis, neuritis, syringomyelia, traumatic paralysis, and hysteria). 6. Torticollis. 7. Empyema and its subsequent cicatricial contraction. 8. Heart disease. 9. Congenital deformities of the spine and thorax. 10. Rickets and osteomalacia.

Arthritis deformans, tuberculosis, osteomyelitis, sacro-iliac disease, and other forms of destructive bone disease may be accompanied by lateral curvature of an atypical sort as a symptom and should be differentiated from true scoliosis.

Heredity is a predisposing factor, and adenoids are so frequently present as to have been assigned as a cause. The children affected have generally grown rapidly, and in muscular development and vigor are, in the majority of cases, below the average.

Fig. 373.—Case of Left Total Scoliosis Seen from Above.

Fig. 374.—Lateral Curvature due to Empyema of Right Chest.
Five months after operation (Bradford and Lovett).

Symptoms.—The soundest classification of cases of lateral curvature is into—(1) *postural* or functional, without marked organic change in the structures; and (2) *structural* or habitual, where there is reason to suppose that a permanent change has taken place in the spine and soft parts. The severer structural cases are sometimes called fixed; the division of the affection into three stages has no practical basis.

Postural Scoliosis.—Functional scoliosis, faulty attitude, "lateral curvature without rotation."

The child with total scoliosis,[251, 252] which is generally convex to the left (175 to 19), has frequently round shoulders and stands with the body displaced slightly to the left; the left shoulder is higher than the right, and if one looks down on such a child, the shoulder-girdle is seen to be further back on the right than on the left in relation to the transverse axis of the pelvis. When the child bends forward at the hips, making the trunk horizontal, the right side of the back is generally more prominent upward than is the left. This phenomenon has been much discussed and spoken of as reverse rotation, retrotorsion, etc.

FIG. 375.—MODERATE ROTATION OF THE RIGHT CHEST BACKWARD AS SEEN IN THE FORWARD BENT POSITION IN A RIGHT DORSAL CURVE.

The whole attitude is merely the one that any normal spine must assume when made convex on to the left in the lower dorsal or dorsolumbar region. Any inequality in the length of the legs or in the strength of the muscles of the two sides of the back; a slight asymmetry of the skeleton, or an error in vision causing a tilting of the head, which causes a curve of the spine to the side, must result in the attitude found in total scoliosis.

FIG. 376.—SEVERE CURVATURE DUE TO RICKETS (Bradford and Lovett).

Such curves may persist unchanged as total curves; they may be cured, or they may change into compound structural curves.[254]

Structural Scoliosis. — Such curves may be "simple" where only one curve exists, or "compound" where two or three curves in alternating directions are found. They are more noticeable than postural curves and are permanent, not disappearing on suspension. Their chief characteristic is found in the presence of a rounded prominence of the ribs or back, found opposite the curve on the side of the convexity of the lateral curve in all cases, and never, as in postural cases, on the opposite side. This "rotation" is most evident when the patient bends forward with the trunk horizontal, when it appears as an upward prominence.

This rotation element is the result of the change in shape of the vertebræ which have yielded to the unequal superincumbent weight and have changed in shape, turning always, as they must, toward the convexity of the lateral curve.

The curved region is stiff in motions, and the mobility is greater to one side than the other. Distortions of body outline, prominence of one hip, elevation of one shoulder, and a lack of symmetry in various directions are the expression of the spinal distortion. The curves are called right or left, according to the direction of their convexity, and are named cervical, dorsal, or lumbar, according to their anatomic situation. If they embrace two regions, they are called cervicodorsal or dorsolumbar.

Fig. 377.—Severe Case of Spastic Paralysis. Patient had never walked and from childhood had sat to one side (Bradford and Lovett).

Fig. 378.—Left Dorsolumbar Curve due to Infantile Paralysis.

Schulthess' table gives an idea of the relative frequency of the different curves in Germany, the material analyzed being patients received for treatment.

	Left Convex.	Right Convex.	Total.
Total scoliosis	156	19	175
Lumbar	71	63	134
Dorsolumbar	182	39	221
Dorsal scoliosis	112	105	217
Dorsal compound curves	66	282	348
Cervicodorsal	26	16	42
	613	524	1137

This confirms common clinical experience that left curves are more frequent in the lower spine and right curves in the dorsal region.

The commonest compound form is the right dorsal left lumbar type; in such a case the right shoulder is raised, the body displaced to the right, and the right arm hangs further from the side than the left. The right side of the chest is prominent backward and the left side of the lumbar region. The dorsal and lumbar concavities may be increased or the back may be abnormally flat.

In a left lumbar curve the trunk is displaced to the left, the right ilium is uncovered and unduly prominent, and the left side of the body flatter than normal at the waist. The backward prominence of the left side of the lumbar region is noticeable.

Pain is infrequent, and noted chiefly in neurasthenic women and in severe cases where real nerve-root pressure exists. In the severest cases pain may be caused by the rubbing of the lower ribs against the crest of the ilium. Shortness of breath, impairment of general health, severe indigestion, and abdominal pain are often the accompaniments of the severer cases. The figures already quoted show the susceptibility of such patients to pulmonary affections.

FIG. 379.—BACKWARD PROMINENCE CAUSED BY THE ROTATION OF THE THORAX ON THAT SIDE IN A RIGHT DORSAL CURVE.

FIG. 380.—POSITION FOR DEMONSTRATION OF ROTATION.

Left dorsal curvature showing severe backward rotation of left side of thorax (Lovett).

Diagnosis.—Any permanent deviation of the spine from the median or sagittal plane of the body constitutes scoliosis. The spinous processes should be marked with a flesh pencil and a plumb-line hung behind the patient in the line of the cleft of the buttocks; in a normal spine the marked spinous processes will lie in this plane. If they deviate from it laterally in a noticeable curve, scoliosis is present.

It must then be determined whether the case is postural or structural. Certain indefinite cases, evidently transitional from total postural to compound structural curves, will be seen, which present certain features of both postural and structural curves. For examination the patient should be seen with the back always bare to the level of the trochanters.

It is important to differentiate from the static varieties the lateral curves of Pott's disease and arthritis deformans. In both of these the lateral curve is symptomatic and associated with stiffness of part or all of the spine, with muscular rigidity and with pain on movement. The other diagnostic signs of these conditions are also present.

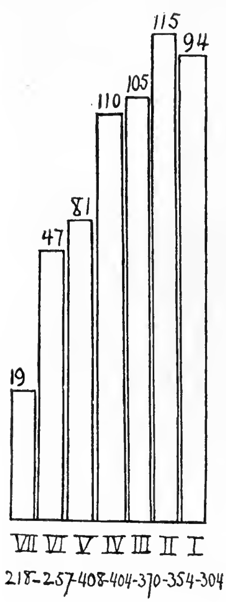

Fig. 381.—Diagram Showing the Progressive Increase of Scoliosis during School Life. The lowest grade in school is placed on the left. The lower figure shows the number of children investigated in each grade, and the figure at the top the number of scolioses found in each grade (Scholder).

Prognosis.—The prognosis of postural lateral curvature as to spontaneous outgrowth is not favorable, and the frequent error made by practitioners of advising no treatment and assuring the parents that the malposition is of little importance frequently leads to serious results. Postural scoliosis is in many cases at least a preliminary stage of the structural form. Total postural curves were observed to change to structural curves in 26 out of 86 cases observed by Hess[256] for varying periods, the average of which periods was one and one-third years. It cannot be told in any given case, by any data now at hand, which cases will progress to severer forms and which will remain stationary. In cases of average development under proper home conditions the cure of postural scoliosis may be looked for under proper treatment continued over a sufficiently long period. When changes in the bone have occurred sufficient to cause rotation of the vertebræ on the side of the convexity of the lateral curve, no spontaneous improvement is to be looked for, but, on the contrary, a progressive tendency toward increase of the deformity. The prognosis is better when the treatment is undertaken in younger patients than in older ones; and the less the amount of deformity present, of course the better is the outlook. It is least favorable in cases due to congenital malformation, empyema, heart disease, rickets, and anterior poliomyelitis. In other cases not having reached extreme grades, in young children, a practical restoration of symmetry from adequate and long-continued treatment is to be expected with occasionally a disappearance of the curve and rotation. In adults, up to the age of thirty at least, some improvement in position and consequent amelioration of the general condition is to be expected from efficient treatment.

Treatment.—Prophylaxis.—Scoliosis is apparently, in most cases, in a measure at least, due to faulty attitudes of sitting at school and faulty attitudes of standing and sitting at home. The writing position is especially vicious.[257] In the Lausanne investigation the percentage at different ages rose grade by grade from 8.7 per cent. in the lowest grade to 31 per cent. in the highest.[237]

The first point in the prophylaxis is the institution of proper school hygiene. This consists of intelligently arranged periods of study, correct lighting and ventilation of the room, the use of modern adjustable school furniture,[259] and the adoption of some exercise periods to break the long hours. The avoidance of excessive bodily and mental fatigue in rapidly growing children is to be advocated, of course, on general grounds, as well as for the prevention of lateral curvature.

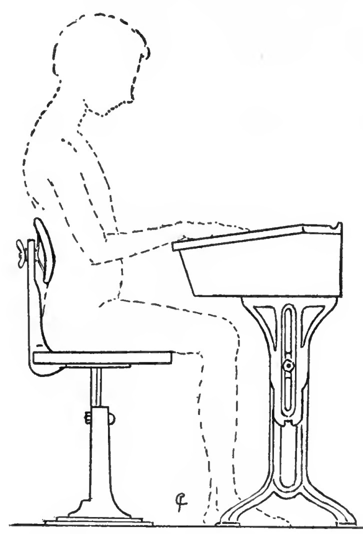

FIG. 382.—DIAGRAM OF ADJUSTABLE SCHOOL CHAIR ADOPTED BY THE BOSTON SCHOOLHOUSE COMMISSION (F. J. Cotton).

Treatment of Postural Cases.—A child with postural lateral curvature should be placed under proper hygienic conditions at school and at home,[237, 257] and the day should be so shortened as to avoid excessive activity and consequent fatigue. The clothing should be supported from the waist, and not hung from the shoulders, and errors of vision should be corrected. If one leg is longer than the other, the short leg should be built up by a high sole to an equal length. If the muscular tone is poor and the child constantly fatigued, the treatment will be unsatisfactory.

The treatment should be essentially gymnastic, with a view to cultivating those muscles which are concerned in maintaining the erect attitude. The type of exercises required are embodied in the "setting-up drill" of the army recruit. The treatment of such cases may be carried out, under the surgeon's supervision, by any competent gymnasium teacher who will see that the work is sufficiently pushed. The causes of failure are, giving too light work, stopping gymnastic work too soon, and giving complicated exercises. Beginning with half an hour daily of sharp muscular work in from two to four weeks the period should be increased up to three-quarters of an hour or an hour daily. After an active period of about this amount or longer home gymnastics of a simple type should be done for some months and the patient inspected occasionally.

Braces and corsets are not indicated in this form of lateral curvature. If round-shoulders exist, they should be treated as described.

Treatment of Structural Lateral Curvature.—The treatment of structural lateral curvature presents a definite surgical problem to be met only by rational and adequate means of treatment. To put a brace or corset on such a spine in the position of deformity, or to give light and inefficient exercises, is no treatment at all.

Treatment, therefore, falls at once into two divisions—(*a*) to restore flexibility and secure thus the possibility of improved position in the curve and (*b*) to retain the spine in this improved position.

The measures commonly adopted are as follows:

1. *Active exercises* (side bendings and the like), given in the free standing position, are sufficient *only* in the milder cases to loosen up the curve and secure improvement. The pelvis should be fixed in order to localize the movements in the spine, and the spine is then exercised in such a

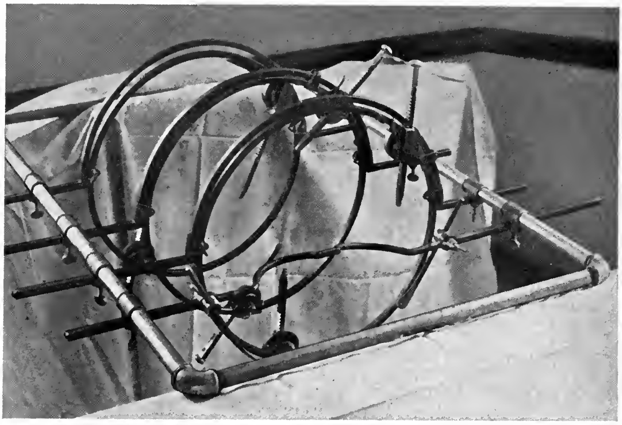

Fig. 383.—Apparatus for Forcible Correction by Plaster Jackets.

way as to straighten the curve. Periods of from one to two hours a day of vigorous work must be continued daily for some weeks before appreciable result can be reached. Free standing muscular work must consist of simple exercises, anatomically sound, which work directly on the curved portions and which can be seen to straighten them, whether symmetric or asymmetric. Such exercises will be found described in special works[262] and cannot be entered on in detail here.[263]

2. *Exercises in apparatus* are more definitely to be localized and are not only intended to restore flexibility, but at the same time to increase the power of the muscles to hold the improvement. Such apparatus reaches its highest development in the machines devised by Schulthess,[264] but on account of their expense and complicated construction, they are but little used in America.

3. *Improvement of Flexibility by Passive Stretching.*—If a patient is suspended by a Sayre head sling or suspends herself by the arms from a

bar, the body weight tends to straighten the spine and diminish both rotation and side curve. This application of the force takes more effect on the movable than on the stiff portions of the spine, but is effective so far as it goes. The least economic way of straightening a bent stick is to pull its two ends apart. The greatest side displacement is to be secured with the patient prone without traction, and with the force to be used split into its two elements, one to correct rotation and the other to correct the side deviation. A simple machine has been devised to accomplish this by economically applied force. The patient lies prone on a low wooden table, with the pelvis resting on a board and held by two clamps over the ilia. The middle of the table is split into three transverse pieces, each of which can be rotated and pulled to the side on a center in the long axis of the body. By means of pads, rotation and side deviation can be corrected at any level, and the lumbar region pulled and rotated one way and the dorsal in the opposite way, while the shoulders are held independently in any desired plane. This apparatus is used for intermittent stretching for as long a period as possible daily.

Correction by Jackets.—In severe structural cases a corrected position and increased flexibility can be most quickly obtained by means of plaster jackets applied to the spine in a corrected position. The greatest correction is to be obtained with the patient prone without traction, by the use of direct pressure, split into its two components at each level, one for the correction of the lateral curve and one for the correction of the rotation. Jackets may be applied by means of the apparatus shown in Fig. 383.

Such jackets are worn from one to two weeks, when a second correction is made and a third, if further correction seems indicated, or the corrective jacket may be left on for a year or more with a deliberate intention of making the child grow to the shape of the jacket. The continuous force exerted is very great, and sloughs are to be avoided only by careful padding. After the removal of the last jacket a removable jacket is applied and the last jacket filled with plaster-of-Paris and water, and used as a cast for the manufacture of a permanent corset.

Retention of the Improved Position.—The second part of the treatment now to be discussed deals with retaining and securing as a permanency this improved position. To make a spine more flexible without providing for muscular development and support if necessary, is an injury to the patient, because a worse position than the original one is thus made possible.

Gymnastic Treatment.—A permanent recovery must obviously depend on the strengthening of the muscles which maintain the corrected position, and exercises should be directed to that end. Any muscular contraction that secures an improved position is therapeutic so far as it goes. (*a*) As an example of this type of exercise is the following: The patient stands erect, and under direction draws the spine by muscular effort into the best possible position and holds this position. At first this is accomplished more easily if the hands are placed on the hips or the head. (*b*) In general it has been found empirically that the extensors of the back should be strengthened to contribute to an improvement of the lateral curve, and such exercises in connection with contraction of the muscles on the convex side of the curve form a common type of exercise. In a right dorsal or dorsolumbar curve the patient lies on a table with the arms behind the head and rises and bends to the right.

(*c*) As an example of the contraction of the muscles on the convex side of the curve is the following: In a left lumbar curve the patient hangs by the arms and lifts the straightened legs to the left, or lies prone on a table and approximates the left side of the pelvis to the left side of the thorax by drawing up the left side of the pelvis while the left leg is held.

(*d*) It has been demonstrated that the symmetric contraction of all muscles maintaining the erect position, brought about by raising a heavy bar or a heavy pair of dumb-bells over the head,[265] is a gymnastic exercise of value in establishing the maintenance of the corrected position. The patient should exercise daily with dumb-bells, at first light and then rapidly increasing to bells from 5 to 20 or 30 pounds each, and bars weighing from 10 to 30 pounds are also required. At each exercise period the patient should be exercised to the limit of fatigue.

But whatever gymnastics are given, they must work the patient to the limit of fatigue and occupy from one to three hours daily at the outset. Great discredit has fallen on the gymnastic treatment of scoliosis, first, because complicated exercises of an ineffectual character sanctioned by tradition have been used, and, secondly, because the work has been in most cases altogether too light and infrequent.

Braces and Corsets.—Support by apparatus must be regarded as necessary when the patient does not hold from one exercise period to another any improvement in position and following forcible correction. A plaster-of-Paris jacket is applied to the patient suspended by a Sayre headpiece, and is at once removed, or the last corrective jacket is preserved when cut off. This jacket is filled with plaster-of-Paris and a mold thus secured. This mold or torso is then cut with a spoke-shave where it is prominent on the side of the curve, and built up by plaster on the other side until it is symmetric or overcorrected by being filled out as described. In the severest cases the whole figure should be reversed, the prominent side of the thorax made flat and the flat side prominent, and in the same way the contour of the hips reversed. Such a mold is smoothed and shellacked and a removable corset of plaster, leather, celluloid, papier-mâché, or the like, formed to it over a layer of stockinet or an undershirt, and then cut off to be fastened down the front by lacings.

Operation.—Severe structural scoliosis has been operated on a few times with indifferent success. Volkmann proposed and carried out a resection and shortening of the ribs of the convex side, and Hoffa also operated in a similar way. Hoke[268] operated on a young adult, lengthening also the ribs on the concave side, and following the operation by the application of a corrective jacket. The improvement in the latter case was marked. The advisability of the operation is not yet established. In general the purely gymnastic treatment of structural scoliosis is unsatisfactory in all but the lightest cases, and forcible correction constitutes in general the proper treatment in cases attended by any degree of bony deformity.

ROUND SHOULDERS.

Synonyms.—Round back; kyphosis dorsalis arcuata. German, runde Rücken; habituelle Kyphose. French, dos vouté. Italian, schiene rotonde.

This is a stooping attitude of static origin, the result of rapid growth, muscular weakness, and faulty attitude, which begins in children and may be recognized as early as five years of age, but most cases come to the attention of the surgeon somewhat later, especially in school-girls approaching the age of puberty. The causes are to be sought in improper school furniture, sitting in bad positions at home, over-

Fig. 384.—Round Shoulders.

Fig. 385.—Round Hollow Back.

work, bad air, poor food and unfavorable hygienic conditions in general, rapid growth, and suspending the weight of the clothes from the tips of the shoulders by the ordinary type of child's waist.

There are three chief types: (1) where the whole back is curved in one posterior bow, spoken of as "round back"; (2) where the backward dorsal convexity and lumbar forward convexity are both increased, called the "round hollow back";[22] and (3) forward displacement of the shoulder girdle when the shoulders are held forward. Cases may be either flexible (permitting reposition) or resistant.

The diagnosis is made by finding the spine perfectly flexible, the general condition almost invariably muscularly weak, and by the absence of the

Fig. 386.—Patient Before Correction (Nov. 9, 1903).

Fig. 387.—Patient after Correction and Removal of Jacket (Nov. 12, 1903).

diagnostic signs of Pott's disease, with which the affection may be confused.

The **prognosis** without treatment is not good so far as the spinal curve is concerned, but for recovery under proper treatment the outlook is excellent.

The **treatment** consists of the improvement of the hygiene so far as possible, especially in the lessening of the work at school, the use of proper school furniture, and in the proper arrangement of the clothes.

The muscles should be developed by daily gymnastics properly performed under careful supervision. The muscles and shortened tissue must be stretched, and the gymnastic prescription should not differ essentially from the "setting-up drill" of the army recruit. Supporting braces should be avoided if possible, as they cannot be regarded as treatment, but simply as a means of holding the patient between treatments.

DEFORMITIES OF THE SPINE.

There are certain deforming affections besides tuberculosis which cause backward deformity of the vertebral column nearly resembling the deformity of Pott's disease. These are comparatively rare. They are spondylitis typhosa (typhoid spine) and traumatic spondylitis.

Typhoid Spine (*Spondylitis Typhosa*).—This name was applied by Gibney to a painful affection of the spine occurring occasionally late in typhoid fever, in which symptoms resembling those of very acute Pott's disease arise without apparent cause. The affection is comparatively infrequent. Twenty-six cases were collected and analyzed by Lord[18] in 1902.

The **pathology** of the affection has not been established by sufficient postmortem evidence. It was originally supposed to be a perispondylitis, and later Osler[17] called attention to the nervous symptoms of the condition, believing it to be largely a functional neurosis. The present view, and apparently the soundest one, is inclined to attribute part at least of the symptoms to an osteomyelitis analogous to that occurring in the other bones in typhoid. This is particularly borne out by such cases as that reported by Lovett and Withington,[27] where a distinct kyphosis formed in the spine and yet hysteric symptoms were present. In 18 cases reported by Moorehouse[28] deformity was recorded as present in 6 and in 6 deformity was stated not to have occurred. It is significant that the involvement of the spine in a similar process has been recorded in pneumonia and influenza.[18]

The spinal **symptoms,** which come on during the latter part of typhoid fever, are extremely acute. The real condition is likely to be overlooked, and the pain at first attributed to something else, as, for example, pleurisy or neuralgia. It is generally seated in the lower dorsal or lumbar region, and becomes rapidly worse; soon even the slightest motion becomes extremely painful, and gaping, sneezing, and movements of the arms are accompanied by suffering. The symptoms, however, are confused and not confined to one type, as in tuberculosis of the spine, for nerve-root pains are prominent, the reflexes are disturbed, cramps in the legs occur, and paralysis with involvement of the bladder and rectum are not infrequent. The presence of the stigmata of hysteria in many of the cases is to be expected and does not exclude the existence of typhoid spine.

The **diagnosis** must be made largely on the facts mentioned, and any form of pain in the back occurring in later typhoid fever should be diagnosticated with very great care. The prognosis is good.

Treatment.—The spine should be fixed as soon as a reasonable diagnosis is made. The patient should not be left to roll round on a mattress, but should be placed on a gas-pipe bed-frame at the outset. Prolonged recumbency is undesirable, and as soon as the very acute stage of the condition is over, the patient should be treated by a Taylor brace or the application of a plaster jacket.

Spondylitis Traumatica.—Spondylitis traumatica is the name applied to a deformity following accident, the identity of which has been seriously questioned. It was described by Kümmel,[19] and several cases supposing to fall in this class have been recorded. The symptoms described are as follows: After an accident involving considerable traumatism of the spine there follows a period during which spinal motion is painful and a certain amount of disability may exist, subsequent to which time the symptoms may clear up, but a new discomfort is noticed after a few months, however, with symptoms similar to those of mild Pott's disease and accompanied by a deformity generally rounded in character, which is permanent.

The assumption of a traumatic osteitis of the vertebræ is not supported by pathologic evidence. In view of the fact that some of the cases are the late results of fractures; that some are clearly cases of spondylitis deformans following accident, and that other cases are evidently tuberculous in character, the existence of such an entity must be seriously questioned. The treatment is identical with that of Pott's disease.

Malignant Disease of the Spine.—A destruction of the vertebral bodies closely resembling that of Pott's disease occurs in the somewhat rare cases of sarcoma and carcinoma of the spine.

The symptoms are similar to those of Pott's disease, and pain of a very severe grade is almost always present, accompanied in many cases by symptoms of nerve-root pressure. Paralysis is frequently present.

The diagnosis from Pott's disease, and sometimes in the dorsal region from severe intercostal neuralgia, is difficult and at times impossible, although help may be obtained from the severity and the persistence of the pain in spite of large doses of morphin, from the use of the *x*-ray, and possibly from the presence of malignant disease elsewhere.

The prognosis is bad, and the treatment consists in relieving pain so far as possible by the measures mentioned in speaking of Pott's disease.

Syphilis of the Spine.—In the history of late syphilis a backward projection of the spine occasionally occurs where gummata have formed in the vertebral bodies, causing them to collapse. Exostosis of the vertebræ is occasionally found.

The diagnosis in many reported cases has rested upon very slender clinical evidence, but certain cases are well authenticated. The affection is so rarely recognized that little can be said of its clinical course.[20]

Actinomycosis of the spine is a rare cause of spinal deformity. It is recognized by the presence of great induration and by recognition of the fungus in the tissues.

Arthropathy of the vertebral column in connection with organic nervous disease of a degree sufficient to cause deformity has been recorded in 26 cases.

Osteomyelitis of the spine and **arthritis deformans of the**

spine are two conditions causing at times the formation of kyphosis, but they are considered in their appropriate sections.

Kyphosis.—The name kyphosis designates an increase in the backward curvature of the spine, whether local or general. The deformity occurs in connection with several conditions, the most frequent of which, apart from Pott's disease, is round shoulders.

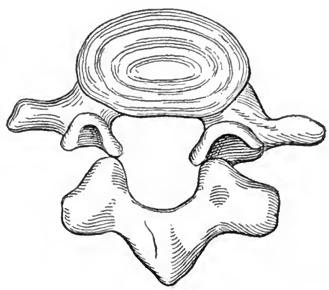

Fig. 388.—Specimen from the Museum of Kolliker at Wurzburg. Showing double defect of vertebral arch (Neugebauer).

The other and less common causes of kyphosis, connected, at least in part, with static causes, are as follows:

Occupation necessitating a bent position of the spine, as in cobblers, tailors, etc. Old age, accompanied by atrophy of the intervertebral disks. Osteitis deformans. Secondary osteo-arthropathy; acromegaly; scoliosis; osteomalacia and rickets; and paralysis of the muscles of the back.

The treatment of these will be discussed in the sections dealing with them.

Spondylolisthesis.—The rare condition described by this name consists of forward subluxation of one of the lumbar vertebral bodies. The affection is in many cases traumatic, but it may occur without obvious cause, although a trauma can generally be found in the history. Women are more frequently affected than men, and the disease is frequently associated with pregnancy or labor; hard work is given as another cause.[24]

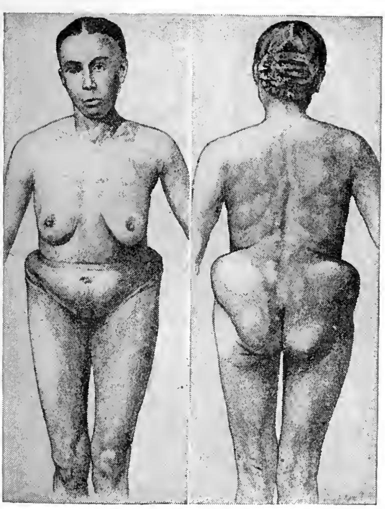

Fig. 389.—Breisky's Case of Spondylolisthesis.

The affection is most often seen in young adult life, and the fifth lumbar vertebra is the one most frequently subluxated, but one case of dislocation of the first piece of the sacrum has been recorded. The condition is not a pure dislocation of the vertebra in most cases, but an elongation of it in the anteroposterior axis. The causes of the separation of the anterior and posterior parts of such a vertebra have been extensively discussed.

The symptoms are a modification in the gait, with some pain and stiffness in the legs; lumbar lordosis is marked, the trunk is shortened, and the equilibrium disturbed; the obliquity of the pelvis is diminished, and there is inability to extend the legs fully. Vaginal examination shows a prominence in the lower part of the spine, and in cases where the affection is more on one side than the other, scoliosis results. Externally the affection resembles Pott's disease, double congenital dislocation of the hip, and rickets.

An *x*-ray photograph is of great value in the diagnosis.

Treatment should consist of fixation if local irritability is present.

DEFORMITIES OF THE CHEST.

Congenital deformities of the chest which arise from anomalies and deficiencies of bones and muscles are unusual, and not of great practical importance. The sternum may be wholly or partly absent, split longitudinally, or divided transversely. The pectoral and serratus muscles may be deficient, one or more vertebræ may be absent, one or both clavicles may be wanting, and malformations of the scapula may exist. The ribs may be deficient or bifid, and fused together in parts. For the most part these defects are not remediable.

Pigeon=breast.—Synonyms.—Chicken-breast; pectus carinatum or gallinatum. German, Hühnerbrust. French, poitrine en carene; poitrine de pigeon. Italian, torcace carinato.

In this condition the sternum and costal cartilages are prominent forward, and the anteroposterior diameter of the chest is increased so that the thorax approaches in type that of a bird.

The condition results—(1) from rickets; (2) in connection with respiratory obstruction from hypertrophied tonsils, adenoid growths, and the like; (3) in dorsal Pott's disease; (4) in some cases of paralysis of the muscles of the trunk.

The affection is often asymmetric, and the costal cartilages of one side may be more prominent than the sternum. Beyond rendering the children liable to bronchial affections and causing some shortness of breath, the affection causes no symptoms.

The slighter cases may be outgrown, but the severer ones are likely to persist into adult life, when, in the case of women, they are objectionable from an esthetic point of view. The frequency with which the deformity is seen in otherwise well-formed adults is striking.

The cause should be removed if possible, and respiratory gymnastics carried out. Hanging by the arms and similar exercises tend to push out the sides of the chest. In severe cases pressure may be made against the prominent sternum by an apparatus consisting of a pad fastened to a back brace or a padded spring truss bearing on the back and on the sternum.

Funnel=chest.[132]**—Synonyms.**—Pectus excavatum. German, Trichterbrust. French, thorax en entonnoir. Ital., pecho en embudo.

In this deformity the sternum and costal cartilages are depressed below their normal level, and the sternum forms a sort of groove down the front of the thorax. The condition is generally congenital, and in its acquired form is not uncommon in a slight degree as an association of rickets and Pott's disease. It is frequently asymmetric, and is more common in males than in females.[134]

The treatment consists in gymnastic respiratory movements to drive out the front of the chest.

Congenital Elevation of the Scapula.[124]—**Synonyms.**—Sprengel's[125] deformity. German, angeborene Hochstand des Schulterblattes oder der Scapula; Sprengelsche Difformität. French, surelevation congénitale de l'omoplate.

The congenital deformity described by this name consists in an upward elevation of one scapula in its relation to the thorax and to the scapula of the other side. The affection is generally single, but cases affecting both sides have been reported.[126] The deformity is rare, 99 cases having been reported up to 1906.

The **etiology** of the affection has been found by some writers in a lack of amniotic fluid, but

FIG. 390.—FUNNEL CHEST (J. S. Stone).

FIG. 391.—CONGENITAL ELEVATION OF THE SCAPULA (Bradford and Lovett).

the presence of bony anomalies and defects brings many cases into the class of deficiencies of development.

Pathologically one finds the scapula elevated, and so rotated that its lower angle approaches the spine more than normal. Some scoliosis is generally present, and there may be associated anomalies of the face and skull, wry-neck, and the absence of bones and muscles, as in a case of Hoffa's in which the radius was deficient. The formation of the scapula follows three types: (1) A bridge of bone connects the scapula and the vertebral column; (2) a long piece of bone projects upward from the upper border of the scapula, but does not articulate with the spine; and (3) the scapula shows no bony outgrowth.

The **symptoms** are simply those of the malposition; the scapula is elevated and the shoulder carried high, there is a slight scoliosis, the neck on the affected side is short and thick, and the trapezius muscle is prominent. The axillary border of the scapula is nearly horizontal, and the function of the arm is generally but little impaired. The upper border of the scapula is prominent and suggests the presence of an exostosis. An *x*-ray is of value in establishing the diagnosis. In double cases these signs are present on both sides.

The **treatment** in childhood consists in the division, through an open incision, of the muscles retaining the scapula in its elevated position. In adult or adolescent cases but little is likely to be gained by this operation.

INFANTILE PARALYSIS.

Synonyms.—Anterior poliomyelitis; essential paralysis; teething paralysis; spinal paralysis; infantile palsy. German, spinale Kinderlähmung; essentielle Kinderlähmung. French, paralysie infantile; paralysie spinale; paralysie des petites enfants.

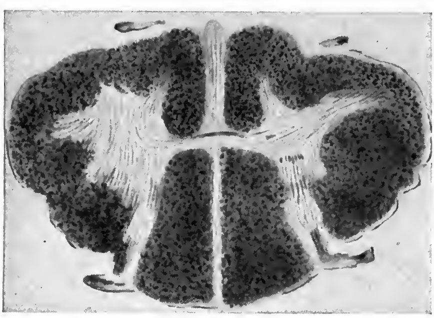

Fig. 392.—Anterior Poliomyelitis. Chronic Stage.

Section through sixth cervical segment; diminution of anterior gray matter and of entire half of right side (Sachs).

Infantile paralysis is a disease of frequent occurrence. In 12,694 orthopedic cases in children under twelve applying at the Children's Hospital, Boston, there were 987 cases of infantile paralysis. It affects most often children under four, 472 out of 599 cases occurring before that age. It occurs most frequently in summer, 213 out of 270 cases having begun during the months from May to September inclusive. The affection is often epidemic in character.

No organism causing the affection has as yet been identified. It attacks healthy children, as a rule; the attacks come on in the night rather than in the day, and although a fall, a chill, and other incidental causes are assigned, we know nothing of the predisposing causes of the affection.

Pathology.—The changes are most marked in the anterior cornua of the spinal column, although apparently the process is an interstitial inflammation resulting in secondary changes in the ganglion-cells. Secondary degenerations follow from the focus of the attack, following the anterior nerve-roots and extending to the motor nerves and muscles.

Atrophy and retardation of growth of the affected muscles and bones occur; the bony epiphysis becomes stunted, and the ligaments and capsule of the joints of the affected limb become relaxed.

Symptoms.—The onset is generally accompaned by some fever, and vomiting, delirium, and convulsions may be present in some of the cases. On recovery, however, it is found that a paralysis of greater or less extent is present. Pain and hypersensitiveness, which reach their maximum almost at once, are likely to accompany the onset of the

Fig. 393.—Paralysis of Both Legs, Knock-knee, Flexion of Knees, and Talipes Equinus (Bradford and Lovett).

paralysis. Second attacks are very rare and occur within a few days of the original onset.

The paralysis may occur suddenly without any general disturbance.

The paralysis is a motor one of certain groups of muscles, or certain isolated muscles, picking them out apparently more at random than by their anatomic or functional association. It may be complete of one or both limbs, or it may affect only certain motions of the foot. The paralysis in its distribution is monoplegic in about half the cases.

Atrophy is marked and rapid; shortening begins early in the history of the disease, and when the paralysis is well established, the circulation is sluggish and the leg colder and more blue than the other. It is essentially a disease of the lower extremities, paralysis of the arm being comparatively rare.

Diagnosis.—In the initial stage the onset may cover the real condition and the diagnosis of typhoid fever, rheumatism, or cerebrospinal meningitis may be made and the real condition overlooked. In the established paralysis the diagnostic points are the existence of a motor paralysis, most often monoplegic in type, frequently paraplegic, but very rarely hemiplegic. The affected member is wasted, blue, and cold, certain motions are absent, and muscular contraction of certain groups may or may not be present. The reaction of degeneration in the affected muscles is of much importance; irritability to the faradic current is diminished or lost, and the tendon reflexes are lost in the affected muscles.

Prognosis.—The danger to life in infantile paralysis ends with the

Fig. 394.—Method of Progression in Severe Infantile Paralysis of Both Legs.

first days of the attack, the disease even then being rarely fatal. All cases improve for from one to two months with fair rapidity; then slowly for two or three months more, when they are likely to become stationary. Improvement is extended and made more marked by proper treatment. The tendency of muscular contraction to occur late in the disease is to be noted, and such contractions impair the usefulness of the limb. Shortening is to be remembered in formulating the prognosis.

In the moderate cases, where some of the muscles are left unattacked, brilliant results are to be obtained by tendon transplantation in many cases.

Treatment.—For the onset no treatment likely to be of use has been formulated. When the paralysis is fully developed, the limb must be supported in a position of usefulness and deformities must be prevented or corrected.

In complete paralysis of the leg, if weight is borne upon the limb, the knee flexes and the patient falls. The problem of treatment consists in keeping the knee extended by apparatus. If both legs and hips are paralyzed, along with some paralysis of the muscles of the trunk, a leather jacket with joints opposite the trochanters will probably enable the patient to get about on crutches. If the back is paralyzed, the support of a jacket is necessary.

FIG. 395.—INFANTILE PARALYSIS. RIGHT LEG SHORTENING AND ATROPHY. DROPPED FOOT.

FIG. 396.—SUPPORTING BRACE FOR INFANTILE PARALYSIS OF THIGH WITH VARUS DEFORMITY OF FOOT.

FIG. 397.—CALIPER SPLINT FOR INFANTILE PARALYSIS.

Deformities Following Infantile Paralysis.—In the deformities of infantile paralysis we are confronted by two conditions demanding treatment: I. Loss of muscular power. II. Deformity. These two factors must be treated separately, and the present consideration relates only to the removal of the deformity.

The treatment of the loss of muscular power has been considered already in speaking of infantile paralysis, and will be further taken up in tendon transplantation.

Deformities of the Foot.—The most frequent deformities seen are talipes equinus or equinovarus; talipes calcaneus; talipes calcaneovalgus, talipes valgus, and pes cavus alone and associated with some of the other deformities mentioned.

The deformity in the mildest cases is, as a rule, easily rectified by the use of a supporting brace, consisting of a steel sole plate and upright, an apparatus which controls the position of the foot. In the severer cases the patient should be etherized and the position of the foot rectified either by manual force or by the division or lengthening of the tendons of the contracted muscles.

Deformities of the Hip.—Flexion deformity is a common type, due to a contraction of the muscles and fascia at the front of the leg. In the milder cases traction upon the leg while the patient is recumbent may suffice to overcome the deformity, but if it proves resistant, division

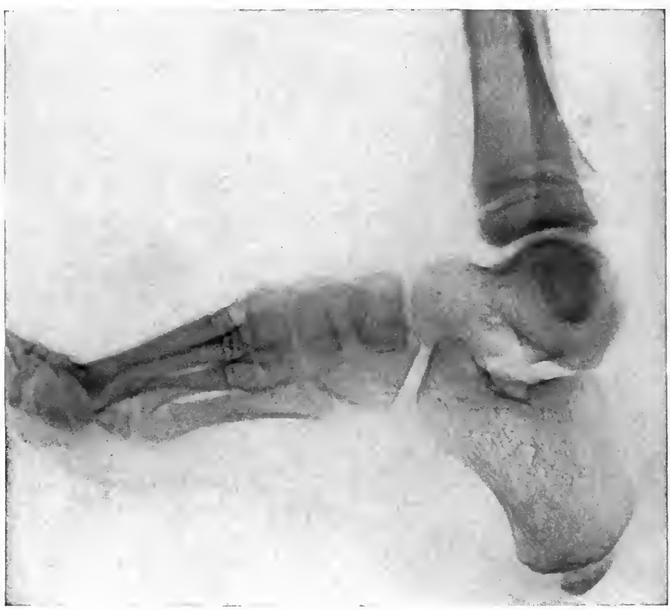

Fig. 398.—Talipes Calcaneus Due to Infantile Paralysis.

of all the contracted parts down to the joint capsule should be made through an incision made just below the anterior superior spine of the ilium. The leg should then be fixed in a plaster-of-Paris spica bandage in an extended position.

Lateral curvature of the spine, of a severe and resistant type, lordosis (an increased physiologic lumbar curve), and kyphosis (an increase of the backward convexity of the spine) may result from paralysis of the trunk muscles.

Deformities of the Knee.—Flexion deformity with subluxation of the tibia occurs as the result of paralysis of the anterior muscles. The treatment consists in stretching or division of the hamstring tendons. Hyperextension of the knee may occur.

In severe and old cases of paralysis of the knee, knock-knee with or without subluxation of the tibia and outward rotation of the leg on the femur occurs and is to be treated by osteotomy.

The significance of the deformities of infantile paralysis is that they must be corrected before mechanic treatment can be satisfactorily carried out, or before tendon transplantation can be satisfactorily performed.

Arthrodesis.—This name is given to an artificially produced ankylosis of a paralyzed and useless joint. The joint is opened, the cartilage sliced off with a knife or cut away by a chisel from the two opposing joint surfaces, and the denuded surfaces left in contact, with the limb in the desired position. The wound is closed and a plaster-of-Paris bandage applied for two months.

Fig. 399.—Paralytic Talipes Equinus.

Fig. 400.—Hyperextension (Genu Retrorsum) of Left Knee from Infantile Paralysis.

The chief use of the operation is found in the ankle. Not only must the astragalotibial joint be stiffened, but all the articulations of the astragalus with other bones must be destroyed, and also the calcaneocuboid joint, otherwise the astragalus may become movable on the other bones and the desired rigidity of the foot on the leg will be lost. The operation should not be done on young children, as a very serious distortion of the foot may occur in later years, apparently as a result of the operation.

At the ankle, which is generally operated on for a flaccid paralysis, it is desirable to shorten the extensor tendons as a further stay to the joint. After the removal of the plaster a supporting brace should be worn for at least six months longer, to protect the newly formed ankylosis. The ankle may be exposed by an anterior or posterior incision, as either gives good access to the joint. The former is preferable, as it enables one to reach the midtarsus through the same incision.

The knee may be ankylosed by arthrodesis, but a permanently stiff knee is a serious inconvenience. Such cases are better treated by a supporting brace which will allow flexion of the knee in sitting. When apparatus is wholly out of the question, arthrodesis of the knee is to be considered.

Arthrodesis of the hip is rarely necessary, and is to be thought of chiefly in connection with paralytic dislocation of the hip.

Arthrodesis of the shoulder may be performed, but is to be replaced by tendon transplantation when healthy muscles are available.

THE LENGTHENING AND SHORTENING OF TENDONS.

Lengthening of Tendons.—Aside from stretching by gymnastics or apparatus or complete division by open or subcutaneous section, tendons are to be lengthened by other means: (*a*) Bayer's[169] method

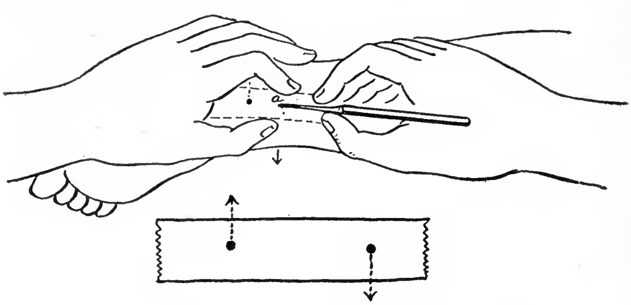

FIG. 401.—BAYER'S SUBCUTANEOUS TENOTOMY (Bayer).

of incomplete subcutaneous division is especially applicable to the tendo Achillis, and is supplanting in many instances the complete division of the tendon formerly in use. The tendon is pierced from behind near its insertion in its middle line by a tenotome pointing directly forward, the knife is turned with the blade to the right, and the right half of the tendon cut transversely at this level. The knife is withdrawn and the tendon again transfixed in the same way an inch above the former place; the blade of the knife is then turned to the left, and the left half of the tendon divided transversely. If strain is now put upon the tendon, the edges of the transverse cuts separate, and the fibers of the part between the cuts slide by each other, lengthening the tendon as shown in the illustration. Any degree of stretching up to three-fourths of an inch is thus obtained, and the continuity of the tendon not broken. If more than this amount of lengthening is desired, the cuts in the tendon must be further apart.

The tendon may be split for any desired length, and two transverse cuts made at each end of the longitudinal cut, one to the right and one to the left. The split parts are then slid by each other until only a small portion remains where they are in contact. Through this portion sutures are passed.

Tendons may be lengthened by complete division and a restoration of continuity by silk sutures passed between the cut ends, or if cut near their insertion, by silk threads prolonging the tendon which are attached to the periosteum. The technic of these proceedings is discussed in speaking of tendon transplantation.

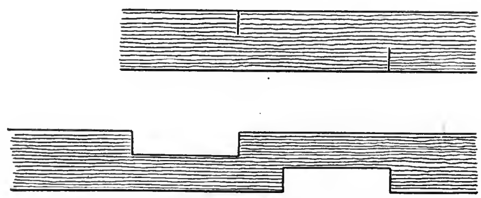

FIG. 402.—TENOTOMY (after Bayer).

Tendon Shortening.—A tendon may be shortened by dividing it completely by a transverse incision, cutting off as much as may be desired and sewing the ends together. It may be divided obliquely and the cut surfaces slid by each other to the desired extent and sutured. It may, however, be shortened without cutting by passing in the length of the tendon two Venetian blind sutures (Fig. 403, *a*), as in Macewen's operation for hernia, and shortening it by puckering it up into a series of transverse folds when the sutures are tightened (Fig. 403, *b*).

Tendon Transplantation[170] (*Tendon Transference; Tendon Anastomosis or Tendon Grafting*).—Tendon transplantation consists in substituting for a paralyzed or disabled muscle the action of a neighboring unaffected tendon. This is done by transferring the distal end of the healthy muscle or tendon into the tendon or point of insertion of the affected muscle.

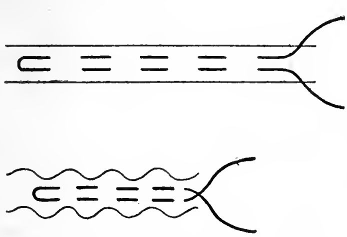

FIG. 403.—TENDON SHORTENING (Hoffa).

The operation is *not* of use when all the muscles of a limb are paralyzed, but only when certain muscles have escaped. If deformity coexists, as is often the case, the deformity must be rectified *first*, if it is severe, and the tendon operation done subsequently.

In addition to infantile paralysis, for which at least 80 per cent. of the operations are performed, the operation has been done for the muscular disabilities resulting from injuries of tendons, overstretched tendons, as in congenital club-foot, in severe knee flexion, contractions from tuberculosis and "rheumatism," in spastic paralysis, in athetosis, in spinal spastic paralysis, syringomyelia, the muscular dystrophies, meningitis, meningocele, apoplectic hemiplegia, rachitic flat-foot, hallux valgus, and pathologic outward rotation of the leg.

There are two methods of operation in use: (*a*) The Nicolodoni method, in which the healthy tendon is sewed into the paralyzed tendon. (*b*) The Lange periosteal method, in which the healthy tendon is inserted into the periosteum.

The earlier method of Nicolodoni, although still defended,[172] has the objectionable feature that paralyzed tendons stretch and that such a muscular insertion is less likely to last than an insertion into periosteum.

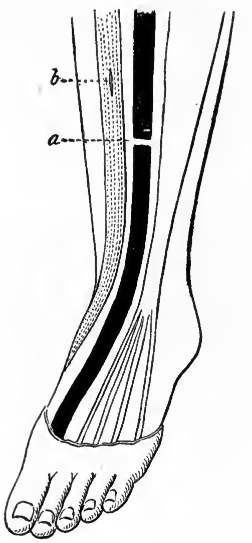

FIG. 404.—PARALYSIS OF ANTERIOR TIBIAL MUSCLE; TRANSPLANTATION OF ENTIRE EXTENSOR HALLUCIS INTO ANTERIOR TIBIAL (NICOLODONI METHOD).

a, Division of active muscle; *b*, slit in paralyzed muscle for insertion of active muscle.

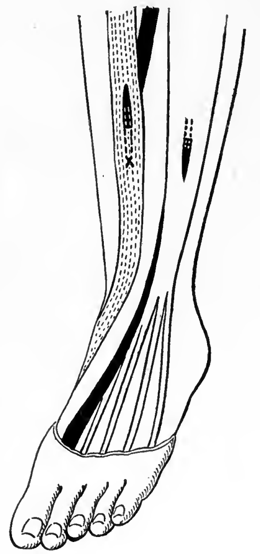

FIG. 405.—MUSCLE TRANSFERRED AND SEWED IN PLACE.

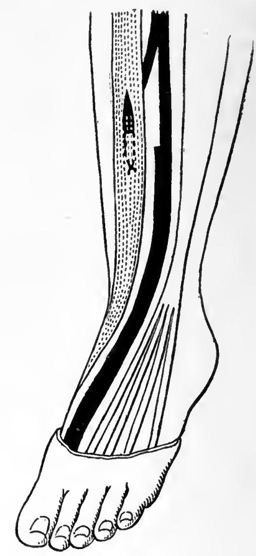

FIG. 406.—TRANSFER OF PART OF EXTENSOR HALLUCIS TO ANTERIOR TIBIAL.

In an experiment on the cadaver, tendons attached to tendons broke under a strain of 2 to 3 kg., whereas tendons attached to periosteum required a breaking force of 14 to 15 kg.[170] Müller[174] has modified the latter method by boring a hole in the bone, through which the tendon is passed.

The whole tendon is generally used, but it may be split in its length[175] and the two halves used for different purposes. For example, in paralysis of the tibialis anticus the extensor proprius hallucis might be split and half cut through, the distal end of the divided half inserted into the tibialis anticus, and the other half left to its original function. The objection to the method is that it is questionable whether the two halves of the tendon ever develop independent function, although it has been claimed.[176] The soundest practice in general is toward the use of entire tendons and toward periosteal rather than tendinous insertion. Simple operations are preferable, except in the most experienced hands, to complicated ones. A plan of operation and a definite anatomic diagnosis are absolutely essential to success.

Operative Technic.—The operation must be performed under the most rigid asepsis, with the limb made bloodless. Free incisions are preferable to small ones, and a free exposure of muscles and tendons is desirable. If the healthy tendon is to be fastened to the paralyzed one and lies close to it, it is either passed through a slit in it and sewed down, or the two tendons are laid together and stitched; but tendons must always be united with the limb in the corrected position, and must be on the stretch. Under other circumstances success is not likely. If the healthy tendon lies at a distance from its point of insertion, a channel is made for it by a blunt dissector, preferably under the fascia, and it is pulled through this channel by forceps. It is desirable not to turn corners in transplanting tendons, but to allow the transferred muscle and tendon a fairly straight course, which is facilitated by free incision.

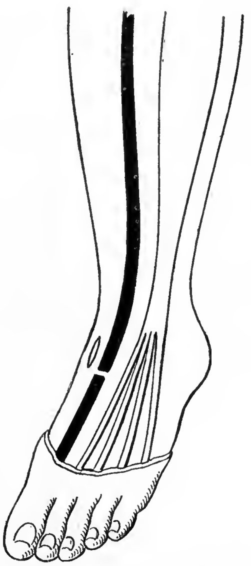

Fig. 407.—Paralysis of Anterior Tibial. Transplantation of Entire Extensor Hallucis to a Periosteal Insertion. Muscle divided and periosteal insertion prepared (Lange method).

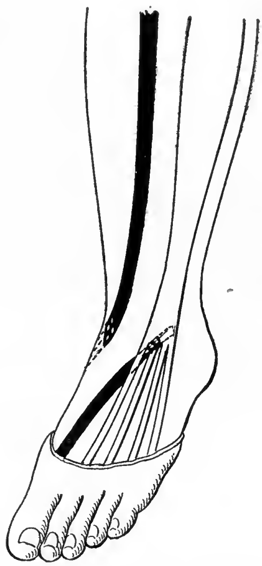

Fig. 408.—Muscle Transferred and Stitched to Periosteum.

If, as is generally desirable, the tendon is to be inserted into periosteum, this is split and pushed back, the tendon laid in the split, and the periosteum and tendon sewed together.

Silk Tendons.—If the tendon is not long enough to reach to its desired periosteal insertion, it may be attached to this location by stout silk around which, as demonstrated by Lange, a tendon will form, thus continuing the original tendon. The silk is attached to the tendon by the method shown in the figure (Fig. 409), and for ordinary tendons four strands are used, but where great strain is to come on the tendon, as in the quadriceps femoris, eight or even twelve strands are to be inserted.

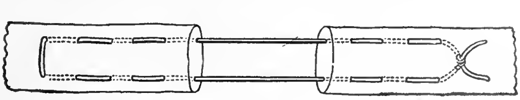

Fig. 409.—Tendon Lengthening (Lange).

The technic of this proceeding is of great importance, as otherwise septic infection is likely. The silk should be boiled, not in water, but in 1:1000 solution of corrosive sublimate. A drain should be put in for forty-eight hours in order to carry away the secretion of fluid in the wound. Necrosis from too much tension on the artificial tendon and from pressure of the knots on the skin is to be avoided. Lange reports 2 per cent. of abscesses from the retention of the silk. The advantage of the use of silk tendons is that it renders one independent of the original length of the tendon to be transplanted, and enables greater freedom in the choice of insertions. Its objection lies in the greater difficulty of technic and the added risk of sepsis.

By one of these methods, then, a healthy tendon has been transferred into a paralyzed tendon or into the periosteum, or has been carried by a silk extension to a periosteal insertion, or part of a healthy tendon has

Fig. 410.—Longitudinal Section through an Artificial Tendon (Lange).

been used in one of these ways, and the limb has been held in a corrected position during the attachment of the tendon. It is not generally deemed necessary to close the tendon sheaths, although this has been advocated. The skin-wound is united, and a small drain of silk or gauze impregnated with 1:1000 corrosive sublimate solution inserted in one end for twenty-four hours.

After-treatment.—In order to avoid too great tension of the skin and consequent sloughs, it is advisable, at the close of the operation, before the application of the plaster, to remove the tourniquet and allow the blood to return to the limb. Areas of skin on the edges of the wound which remain persistently dead white are likely to slough, and the tension on them must be diminished by loosening the sutures. Dressings are then applied, and a plaster-of-Paris bandage put on, holding the limb in an overcorrected position to relax the strain on the transplanted tendons. In operations on the hand this is worn for three to four weeks and massage then begun. In the leg, the patient should remain quiet in the horizontal position for three or four weeks, and in from six to ten weeks from operation the plaster is to be removed, the time depending on the severity of the case and the strain to come on the new tendon.

The limb should then be used in some protective splint to take the strain off of the new tendons for some six to eight weeks more, and massage, douches, and exercises begun after about two to three months from operation. To do a tendon transplantation and allow unrestricted use in a few weeks is simply to invite failure, and such a method is in a measure responsible for the bad results so often reported. The after-treatment is of the utmost importance, and a firm scar is essential for a lasting success.

Applications of Tendon Transference in Infantile Paralysis.—It is not practicable to present a scheme to cover the applications of tendon transplantation, but simply to mention certain typical instances to indicate the methods in use. Vulpius tabulates 116 operations to be performed at the ankle alone.

A definite instance may make the matter clearer. If the tibialis anticus is paralyzed, the extensor proprius hallucis may be cut and inserted into the tendon of the tibialis (Nicolodoni method). A slip of the extensor may be cut from the tendon and inserted into the tendon of the tibialis (partial transplantation), or the whole tendon may be divided and sewed to the periosteum near the insertion of the tibialis muscles (Lange's method).

In *talipes equinovarus* the peronei and common extensor are found to be paralyzed. The tibialis posticus is cut and inserted into one of the peroneal tendons or the periosteum at the outer side of the foot. The extensor proprius hallucis is sewed to the common extensor or into the dorsum of the foot, the tibialis anticus is shortened, and the tendo Achillis lengthened, if necessary, and the foot put up in a position of calcaneo-valgus.

Paralytic Valgus or Flat-foot.—Both tibialis anticus and posticus are commonly paralyzed. The extensor proprius hallucis and some slips of the extensor communis digitorum are sewed to the tendon of the tibialis anticus or into the periosteum near its insertion. The peroneus longus is inserted into the tibialis posticus or the periosteum near its insertion. The tendo Achillis is cut or lengthened, if necessary, and the foot put up in a position of varus with slight equinus.

Talipes Calcaneus.—When the gastrocnemius is paralyzed, the tendo Achillis is shortened, and one or both of the peronei or the tibialis posticus, or perhaps the common flexor or flexor of the great toe, is inserted into the distal part of the tendon or the periosteum of the os calcis. The selection of the tendon to be used will be determined by the position and desired plane of action at the ankle.

Paralysis of the Anterior Thigh Muscles.—The object of the operation is to enable the patient to bear weight on the extended knee by substituting flexors for extensors.

If the gastrocnemius is intact to serve as a flexor of the leg on the thigh, the biceps and semitendinosus and semimembranosus may be cut and carried forward to be inserted near the sides of the patella, into the border of the patella, or made long enough by silk to be inserted into the tibial tendon. The transference of all three tendons insures better power than when one is left as a flexor to antagonize the other two, as at first, at least, they will all contract in response to flexor impulses. If the gastrocnemius is paralyzed, one muscle must be left in place to serve as a flexor of the leg on the thigh.

In paralysis of the anterior muscles of the thigh, if the great muscles at the back of the thigh are weak and the sartorius is left intact, it may be sewed into the fascia above the patella.[180]

In paralysis of the shoulder a slip of the trapezius may be sewed into the paralyzed deltoid or given a periosteal insertion.

In general, operations on the arm are comparatively unusual on account of the slight liability of that member to infantile paralysis. The anatomic conditions are clearer than in the foot, and the indications are different in each case. The transference of tendons in the hands and fingers is easily to be determined by the anatomic needs.

Spastic Paralysis.—Tendon transference in spastic paralysis is less satisfactory than in infantile paralysis, and cannot at present be considered an operation of established utility. So far as the lower extremity goes, a few successful transplantations have been done.

In spastic paralysis of the arm tendon transference is often of value on account of the deficient supination and carpal extension in many cases, which is often severe enough to cause much disability. The pronator radii teres may be converted into a supinator through an incision made in the middle of the front of the forearm. The tendon of the muscle is freed from the radius, passed through the interosseous membrane close to the radius, and the tendon reinserted on the outer side of the radius at its former situation.[185]

The flexor carpi ulnaris may be converted into an extensor by being cut just above the annular ligament, and inserted into the tendon of the extensor carpi ulnaris, and the radial flexor in the same way cut and inserted into the radial extensor.[186, 187]

Another operation consists in separating the pronator radii teres from its origin at the internal condyle, and transferring it to the external condyle of the humerus; the flexor carpi radialis and ulnaris are then divided and inserted into the extensor communis digitorum. The supination and extension of the hand are thus improved.

CEREBRAL PARALYSIS OF CHILDREN.

Synonyms.—Spastic paralysis; cerebral palsy; cerebral, spastic, or infantile hemiplegia; Little's disease; hemiplegia spastica. French, spasme musculaire idiopathique; paralysie cérébrale de l'enfance. German, spastische Gliederstarre; Little'sche Krankheit.

Cerebral paralysis is an affection which manifests itself by a paraplegia, a diplegia, or a hemiplegia. It is characterized by a stiffness, unsteadiness, and irritability of the muscles, accompanied in many cases by mental impairment. It is generally seen in the acquired form.

In 12,694 orthopedic cases in children under twelve seen at the Children's Hospital, there were 310 cases of cerebral paralysis and 987 of infantile paralysis. In 225 cases collected by Petersen and Sachs the distribution was as follows:

Hemiplegia	156
Diplegia	139
Paraplegia	30

Most cases occur at or shortly after birth, the causes being asphyxiation, prolonged and difficult labor, fright, trauma, and infectious diseases, the last-named cases occurring, of course, somewhat later in life. In some cases there is no assignable cause to be found for the attack. The onset may be in some cases severe and closely resembling that of infantile paralysis. From the beginning of the second year the liability to the paralysis gradually diminishes, rising slightly at the time of the second dentition. The disease is about evenly divided between the sexes.

FIG 411.—CASE OF RIGHT HEMIPLEGIA ATTEMPTING TO WALK (Bradford and Lovett).

Pathology.—The changes found are due to embolism or hemorrhage, and the resulting retardation of growth of the affected part of the brain, with secondary degeneration of the cord.

The pathology of the condition is a lesion of the motor area of the brain, with atrophy and retarded development of the affected portion, followed by a descending degeneration of the pyramidal tract and lateral columns of the cord. In some cases the disease originates in defects of the nervous center.

The paralysis is a motor one, accompanied by some bone-shortening, atrophy, and sluggishness of circulation,—in a less marked degree, however, than in infantile paralysis,—the condition in general resembling the hemiplegia of adults. Post-hemiplegic movements occur in many cases. The tendency to aphasia is slight, but mental involvement occurs in the majority of cases, and epilepsy develops in one-fourth or one-half of the cases later in life.

In hemiplegia the foot is in a position of talipes equinus; the knee is somewhat flexed, and the arm held at the side; the affected foot clings to the ground in walking, and the gait is unsteady and distressing. Where both legs are affected and walking is possible, the gait is clinging and unsteady; the balance and coördination are poor; the child falls frequently and walks scraping the feet along the floor at each step, with the knees and hips flexed. In some unusual cases the contraction of the adductors is so severe that the legs are crossed when walking is attempted (scissor-leg deformity).

The spasmodic contraction of the muscles is stimulated by an attempt to use them; on manipulation the muscles feel firm and their resistance is excited by an attempt to stretch them, but by firm and gentle pressure this may be in a measure overcome. Permanent contractions, however, tend to form at all joints of the arm and leg in a position of flexion, except at the shoulder, where inward rotation is evident.

Fig. 412.—Standing Position in Spastic Paralysis of Both Legs.

Strabismus, drooling, and an idiotic expression, with perhaps facial paralysis, are to be found in the severer cases.

Diagnosis.—The disease is to be recognized as a motor disturbance characterized by stiffness and tendency to tonic contraction of the muscles, especially when in use. The tendon reflexes are increased, and there is a tendency to flexor contractions. The disturbance is most often hemiplegic, but may be paraplegic or diplegic. There is no reaction of degeneration in the affected muscles. Athetosis, mental involvement, and epilepsy are common accompaniments.

Prognosis.—The prognosis should be guarded, as the cases lack the strong tendency of infantile paralysis, in its usual stages, toward spontaneous improvement. In general it is far less yielding and satisfactory under treatment than is infantile paralysis, and the fact that so large a proportion of cases develop epilepsy later in life is a matter of the gravest importance.

Treatment.—The mildest cases of spastic paralysis are to be improved by muscle-training, such as is to be found in balancing exercises, rhythmic movements, marching to music, and the like. Contractions are to be prevented, and muscular coördination cultivated.

If the contraction at the ankles, knees, or hips is so great that walking is impeded, the resisting tendon or tendons should be operated on. At the ankle the tendo Achillis is to be lengthened or cut subcutaneously. At the knee the hamstrings are to be divided, preferably by open incision. At the hip the adductor tendons may be divided by open incision or by subcutaneous tenotomy. To correct the internal rotation of the leg, frequent in such cases, Gibney has detached the tensor vaginæ femoris from the crest of the ilium, leaving only its tendinous attachments.[103] After any operation of this sort the child is put up in a plaster spica bandage with the ankles flexed at a right angle, the knees extended, the hips extended and abducted, and the whole leg rotated outward. Retention in this position is desirable for at least six weeks, and a longer time is probably advisable thoroughly to stretch the muscles. Relapse to some extent may occur, but very great permanent improvement is the rule, not only in walking, but in general and intellectual improvement.

FIG. 413.—PARALYTIC DISLOCATION OF RIGHT HIP.

PARALYTIC DISLOCATIONS.

Dislocation of the joints as the result of paralysis is an event of rare occurrence, and except for such dislocations of the hip and shoulder, they occur only as surgical curiosities. These dislocations are the result of the lack of muscular support and the relaxation of the ligaments and capsule incident to the paralysis, and are almost wholly seen in the history of infantile paralysis, the relaxations of locomotor ataxia being generally due to destructive joint disease. Complete dislocation of the joint is practically seen only in the hip and shoulder, the condition in the other joints, when it occurs, being classed as subluxation. The dislocation may occur spontaneously, as in bed; from weight-bearing; or from the weight of the member, as in the shoulder; it occurs in the stage of muscular laxity and contraction.[25]

Paralytic Dislocations of the Hip (*Coxo bot or Hanche bot, Lannelongue*).—Paralytic dislocation of the hip is generally associated with the contraction of certain muscles, for example, the adductors, and the paralytic relaxation of others. The dislocation on to the dorsum of the ilium and the infrapubic forms are seen. Pain and irritability are sometimes present in the affection, leading in some cases to the mistaken diagnosis of hip disease.

Although in the more recent cases, and in some cases of long duration, it is possible to slip the head of the femur into the acetabulum and out again, in the older cases the head becomes more firmly fixed in its new position and easy reduction is not possible.

Definite changes in the axis of the leg take place in growing children, the relation of the axis of the neck of the femur and the normal antero-posterior axis of the leg being decidedly modified.

Prognosis.—Such joints, as a rule, become useful and fairly stable. The shortening stops after a while; a useful contact with the pelvis is established with the head of the femur, and, although accompanied by considerable shortening and eversion or inversion of the foot, with the

Fig. 414.—Paralytic Dislocation.
Radiogram of case shown in Fig. 413.

other changes mentioned, the joint itself may be almost as good as it was before dislocation.

Treatment.—I. According to the condition of the individual case the displaced joint may be let alone, the shortening compensated for, and the leg supported by whatever apparatus it needs, nature being left to establish a false socket.

II. The head of the femur may be replaced in the socket under ether, and retained in position by a plaster-of-Paris spica bandage holding the leg in the position of abduction.

III. The joint may be exposed by an anterior incision, the contracted muscles divided, and the head replaced and held as described in speaking of the bloody reposition of congenital dislocations.

IV. Arthrodesis of the hip-joint can be done, giving a stiff hip.

Paralytic Dislocations of the Knee.—Complete dislocation of the knee does not apparently occur as the result of paralysis. The knee may become loose laterally, as a result of the paralysis, and a position of hyperextension of the knee in standing and walking is frequent in such cases. Finally, the tibia may be subluxated backward as the result of the pull of the hamstring muscles in cases where the anterior muscles have been paralyzed.

Treatment.—The treatment of these cases is covered in speaking of infantile paralysis and tendon transplantation.

Paralytic Dislocations of the Ankle.—Paralysis of the muscles of the leg may result in extensive malposition of the feet in weight-bearing, as in the case of valgus, but such deformities, instead of being classed as subluxations, should rather be described as the various forms of paralytic talipes, such as varus, cavus, calcaneus, equinus, etc.

One case of paralytic dislocation of the ankle outward has been recorded.

Fig. 415.—Paralysis of the Left Arm (Bradford and Lovett).

Paralytic Dislocation of the Shoulder.—Paralytic dislocation of the shoulder occurs as a dropping down of the humerus, carrying the head of the bone away from the glenoid cavity. It is apparently the result of the stretching of the capsule and ligaments produced by the weight of the arm, which is not supported on account of the paralysis of the deltoid and other muscles which should hold it in place. The shoulder is useless, and the affection accompanies a rather severe grade of paralysis.

Treatment.—The treatment consists in the exposure of the joint by an incision, shortening of the capsule, and the transference of a slip of the pectoralis major, trapezius, or other unaffected muscle being inserted to serve as a support to the humerus, where practicable, or arthrodesis of the joint may be performed.

Paralytic Dislocation of the Elbow.—Paralytic dislocation of the elbow is one of the greatest rarities. A case of double subluxation of the elbow has been recorded.

CONGENITAL DISLOCATIONS.

Except in the case of the hip-joint, congenital dislocations are so rare as to be regarded rather as surgical curiosities than as conditions likely to be frequently met. Many dislocations of various joints reported as congenital are really traumatic, occurring at birth, and the term con-

FIG. 416.—ANTERIOR VIEW OF SPECIMEN, SHOWING FROZEN SECTION OF RIGHT SIDE AND PARTIAL DISSECTION OF LEFT SIDE (Allison).

genital dislocations should be sharply restricted to deformities originating during intra-uterine life. They occur both alone and in connection with other deformities, such as club-foot, spina bifida, and the like, and in general no more definite cause can be assigned for them than for other congenital deformities.

Congenital Dislocation of the Hip.—**Synonyms.**—Luxatio coxæ. German, angeborene Huft-luxation oder Huftverrenkung. French, luxation congenitale de la hanche. Italian, lussazione congenital dell' anca.

Congenital dislocation of the hip is an affection comparatively infrequent in general, but by no means rare in orthopedic clinics. At the Children's Hospital in Boston, among 6969 orthopedic out-patients, all children, there were 152 congenital dislocations of one or both hips. The greater frequency of congenital dislocation of the hip as compared to other joints is shown by the figures of Krönlein, taken from the Berlin clinic, where 90 cases of congenital dislocation of the hip were observed during a certain period, in which there were seen only 5 cases of congenital dislocation of the humerus, 2 of the radius, and 1 of the knee.

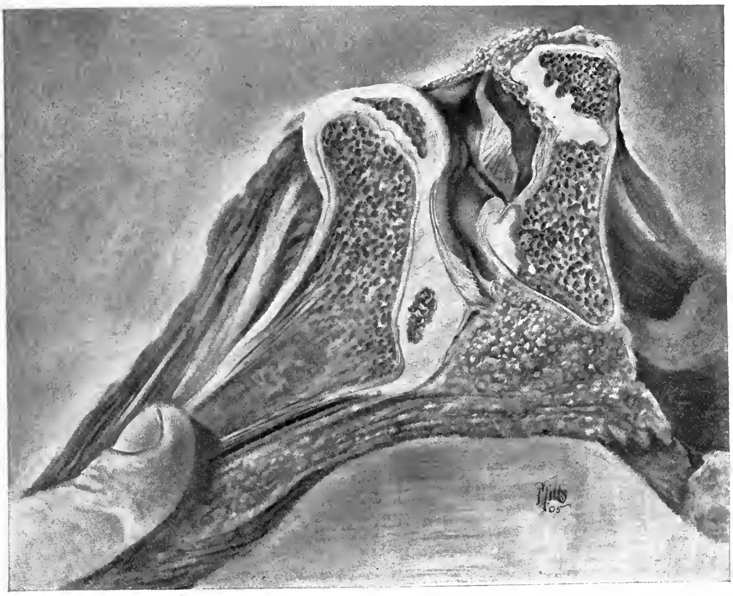

FIG 417.—DETAIL DRAWING OF FROZEN SECTION OF RIGHT HIP-JOINT (Allison).

Females are affected very much more frequently than males; in 1362 cases tabulated by Hoffa[1] there were 173 males and 1189 females; of these cases, 502 were double, 469 affected the left hip, and 592 the right hip.

Etiology.—There is no definite knowledge with regard to the causation of congenital dislocation of the hip, but the explanation that it is apparently a perversion of development due to an unknown cause is the most favored, and the fact of its association with other deformities is of significance in classing it with other deformities in general. Hereditary influence is sometimes to be observed.

Pathology.—The pathologic conditions are as follows: The acetabulum is always present and in the normal situation; it is shallow, generally triangular in shape, and the bottom is filled up by fat and fibrous tissue.

The head of the femur lies above, or above and behind, the acetabulum. At birth the displacement upward is not particularly marked, but with weight-bearing this becomes one of the most important features of the condition. The dislocation found is generally of the posterior variety; the head of the femur is frequently more or less loose, being flattened where it touches the pelvis, while in older cases the cartilage may be found either thinned or thickened, and the shape of the head may present various abnormalities. The neck is twisted to point forward (anteversion), the result of a torsion of the whole upper femur, and the ligamentum teres may be present or absent. In unilateral cases asymmetry of the pelvis is likely to result during the progress of growth, but in double dislocation later in life the pelvis is likely to be deformed and somewhat atrophied, the ilia being pressed in and the acetabula forward, while

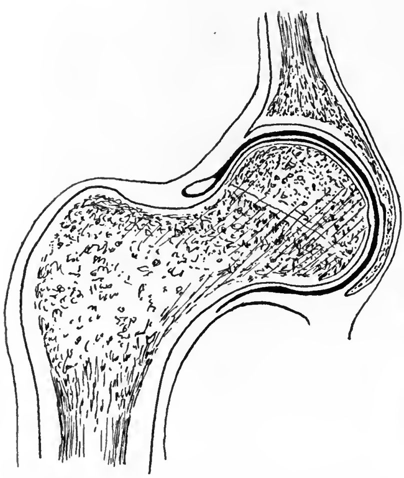

Fig. 418.—Diagram of the Joint Capsule in the Normal Hip (Bradford).

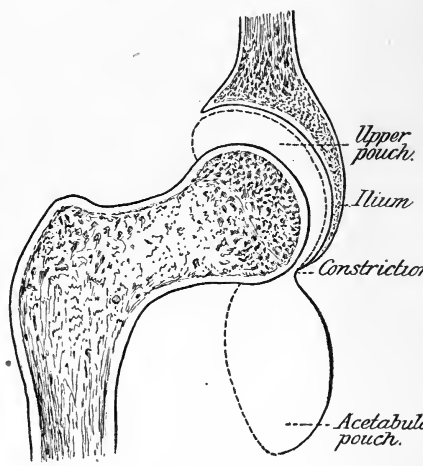

Fig. 419.—Diagram of the Capsule of the Joint after Reduction in a Congenitally Dislocated Hip (Bradford).

in most cases the obliquity of the pelvis is markedly increased because the point of suspension is posterior to the acetabula. Some of the muscles are stretched while others are shortened, those running from the pelvis to the femur being in all cases necessarily changed in their relations.

Inasmuch as the capsule takes the place of the suspensory ligament, the weight of the body rests upon it, and it becomes thickened and stretched. Where it is stretched across the acetabulum it becomes adherent at the rim and to a portion of the ilium, contributing to the apparent obliteration of the acetabulum, and at this point there is found the hour-glass constriction in the lumen of the capsule; the opening in the capsule may be and usually is smaller than the head of the femur, and presents a most important obstacle in the reduction of the dislocation, being frequently carried into the acetabulum before the head of the femur and preventing a satisfactory reposition.

Symptoms.—In double dislocation the children learn to walk late and the gait is characterized by a marked swaying from side to side, while in unilateral cases there is a marked limp, the trochanter and buttocks are prominent, the perineum is broadened, and the patient stands with marked lordosis in bilateral cases. Pain is not often complained of by children. On manipulation the head can be felt to move loosely under the soft parts, not turning in the acetabulum as a center, and a slipping, when it passes over the rim of the acetabulum, may be felt.

Three varieties of the dislocation are

Fig. 420.—Double Congenital Dislocation of the Hip.

Fig. 421.—Congenital Dislocation of Left Hip (Bradford and Lovett).

recognized—the backward, upward, and the forward, the first being by far the commonest kind. In this variety the head can generally be felt under the soft parts posterior to the trochanter, when the leg is rotated inward and adducted. In unilateral cases shortening of the affected limb is present, with a lateral curve of the spine due to this in the standing position.

Diagnosis.—The diagnosis is made by the fact that the trochanter is above Nélaton's line;* that the gait is characteristic; that the head can be felt to slip about during manipulation; that when the child stands on one leg, the opposite buttock drops to a noticeable degree, and that abduction of the leg is limited. The x-ray is of invaluable assistance in making the diagnosis.

Treatment.—*Mechanic or Conservative Treatment.*—As a means of cure the treatment by the use of apparatus no longer holds a place;[68] it is, however, often useful in patients too old or unsuitable for operation for any reason, in whom the slipping upward of the hip-joint in walking may be in a measure prevented by the wearing of a corset of celluloid, leather, or cloth stiffened by steel, with a pad above the trochanter to limit its free upward excursion.

Fig. 422.—Broadening of Perineum in Double Congenital Dislocation of the Hip.

The two methods of treatment in use are: (A) Reduction by manipulation without incision (the "bloodless" method). (B) Reduction by incision and manipulation (the "bloody" method).

(A) The patient is completely anesthetized and laid on the back on a table. The leg is then pulled down by the operator, who makes *strong traction* on the ankle, resistance being furnished by a counter pull in the groin (Fig. 423). The leg is *rotated* outward and inward forcibly with the knee straight and with the knee and hip flexed. It is then forcibly *abducted*, with the knee straight and with the knee and the thigh flexed, until in the latter position the outer surface of the thigh lies flat on the table with the thigh forming a right angle with the trunk (Fig. 424). Abduction to the same degree should be secured with the knee extended. In the manipulation for securing abduction it is necessary to stretch or tear the adductor muscles, a process which is facilitated by massaging them with force when tightly stretched. The leg is then brought straight and forcibly *flexed* with the knee straight until the anterior surface of the thigh touches the chest (Fig. 425). The child is then laid on the face, or with the buttocks at the edge of the table, and the thigh forcibly *hyperextended* with the leg in the long axis of the body and at right angles to it (Fig. 426). These manipulations may be made more forcible by

* See chapter on Dislocation of Hip.

the use of a padded wedge under the trochanter, to serve as a fulcrum for the desired force. This manipulation, which is preliminary to the real reduction, must be forcible and carried out to the extent described above. It is not a gentle pressure to be exercised up to the point of

FIG. 423.—MANIPULATIVE REDUCTION IN CONGENITAL DISLOCATION OF THE HIP. Traction and reduction (Bradford and Lovett).

considerable resistance, but a strong, steady use of force to overcome the resistance. In young children only comparatively slight degrees of force will be necessary; in older children much force must be used and the loosening manipulation may take a long time.

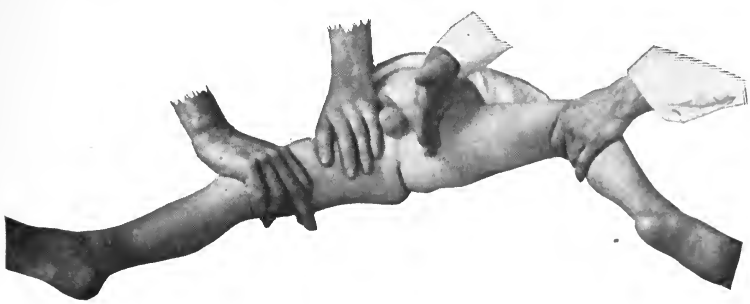

FIG. 424.—MANIPULATIVE REDUCTION.
Forced abduction stretching the adductors, with blows upon the adductor attachment (Bradford and Lovett).

Following the manipulation comes the reduction, which does not differ essentially from that of reducing a traumatic dislocation. The child lies on the back and the hip is flexed and abducted; from this position the knee is lowered, while the free hand of the surgeon presses up against the back of the trochanter and rotates the leg by slight movements one way and the other (Fig. 427). When the case is a favorable one and properly stretched, the head slips easily into the acetabulum,

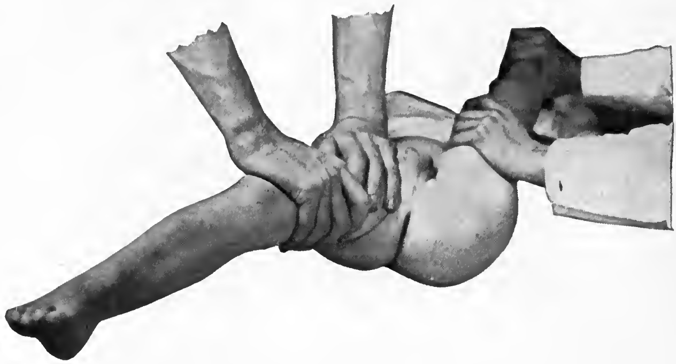

FIG. 425.—MANIPULATIVE REDUCTION.
Forced flexion with leg straight at knee (Bradford and Lovett).

over the posterior rim, with a characteristic click. The reduced head should be felt at the intersection of the line of the femoral artery with a line crossing the pelvis at the level of the symphysis pubis.

FIG. 426.—MANIPULATIVE REDUCTION. HYPEREXTENSION.

The leg should now be brought straight and parallel to its fellow by gentle steady movement. If it slips out in this position, it should be stretched still further. In exceptional very resistant cases reduction may be facilitated by subcutaneous division of the adductor tendons, the iliotibial band, or the fascia lata near the anterior superior spine.

Mechanic Force.—The use of mechanic to supplant manual force in the stretching preliminary to reduction has been made in a machine

FIG. 427.—MANIPULATIVE REDUCTION.
Head of femur pressed into acetabulum by manipulation after all contracted tissues are relaxed by overstretching (Bradford and Lovett).

devised by Bartlett,[70] with the coöperation of Bradford. In this machine accurately localized and carefully graduated force is exercised upon the leg while it is fastened by an extension of leather to a lever movable in any direction, while the pelvis of the patient rests on an iron saddle between two posts firmly grasping it. The trochanter is acted upon by a steel pad working by a separate lever. This apparatus makes possible

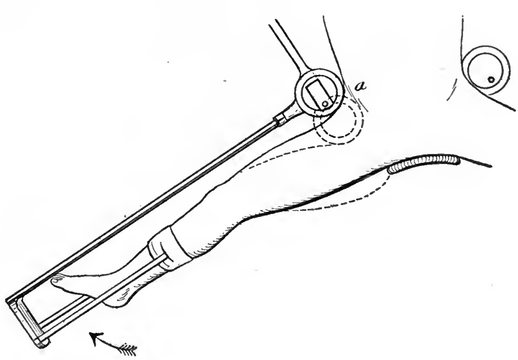

FIG. 428.—DIAGRAM OF THE BARTLETT MACHINE.
The eccentric at *a* forces the head of the femur downward and forward, while the traction rod pulls the head of the femur away from the ilium.

the use of more force by making its application more exact in the resistant cases, and makes bloodless reduction possible in older cases than by the purely manual method.

Dangers of the Operation.—Fracture of the femur or the pelvis, rupture of the femoral artery, temporary or permanent paralysis, suppuration of the extravasations caused by the force used, necrosis of the soft parts, and death from shock are among the accidents recorded. It is evident, therefore, that the method must not be pushed too far nor can excessive force be used with safety. Excessive extravasations are usual and temporary paralyses are not uncommon accompaniments of the operation.

After-treatment.—After operation the child is placed on a pelvic rest of some sort and a plaster-of-Paris spica bandage applied to the leg in a position of right-angled flexion, and so much abduction that the inner

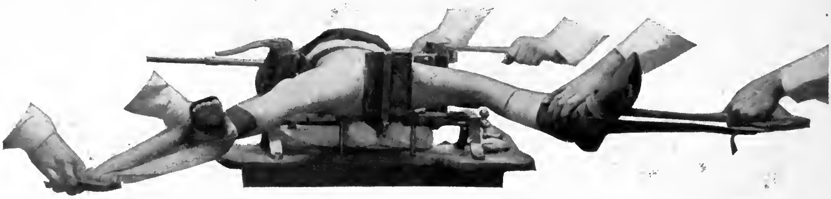

FIG. 429.—BARTLETT MACHINE FOR REDUCTION OF CONGENITAL DISLOCATION OF THE HIP (Bradford and Lovett).

condyle of the femur is at or below the level of the symphysis pubis when the child lies on its back. This bandage should be applied snugly over a layer of stockinet or sheet-wadding, and be heavy enough to hold the joint firmly. It should snugly embrace the pelvis, and may or may not extend below the knee. At first, to permit the laceration of the soft parts to heal, it seems best to carry the plaster below the knee and to keep the child quiet; after a period of two weeks or more the plaster

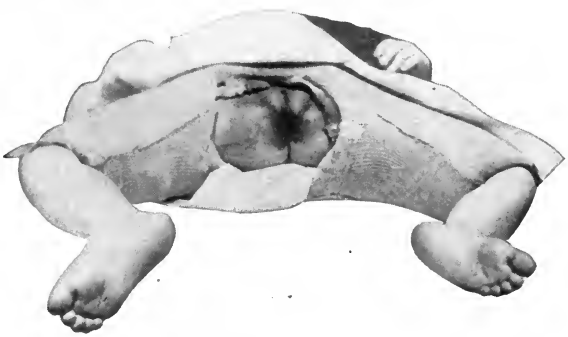

FIG. 430.—PLASTER-OF-PARIS FIXATION AFTER MANIPULATIVE REDUCTION (Bradford and Lovett).

may be cut off above the knee, a high sole put on the affected leg, and the child allowed to walk. This is thought to favor the deepening of the acetabulum, which is "bored out" by the head of the femur. After a period of two to three months the bandage is removed, the hip examined and radiographed, and the leg again put up in a plaster-of-Paris spica bandage in a position of less flexion and abduction. This is again removed after two or three months, the stability of the joint investigated and again reapplied, if necessary. Fixation is generally necessary for a period of about six months, sometimes for a year. As the end of the treatment is approached massage and passive and active exercises should be given.

(B) *Reduction by Incision and Manipulation.*—The child, after anesthetization, is laid on the back and a skin incision made from the anterior superior iliac spine downward and outward, passing below the top of the trochanter (the Lorenz incision), or a longitudinal incision over the front of the joint over the front of the trochanter is made (the Hoffa incision). In the first-named incision the space between the anterior border of the tensor vaginæ femoris and the gluteus medius is opened. The muscles are retracted and the rectus femoris will be found and can be retracted. The capsule of the joint is then split by an incision free enough to expose the whole neck and head of the bone. Cross incisions should be made in the capsule or more superficially if they are necessary.

FIG. 431.—PLASTER FIXATION AFTER REDUCTION OF A CONGENITALLY DISLOCATED HIP.
The foot is raised to improve locomotion (Bradford and Lovett).

The thigh is then flexed to a right angle and the capsule divided at its attachments to the neck, and the trochanteric line both on its anterior and posterior surfaces. The head of the femur is then dislocated, the ligamentum teres extirpated if present, and the head of the femur pulled away so that the cavity of the acetabulum and the upper part of the capsule may be inspected. If the capsule is constricted, it should be divided by a herniotome or stretched by a dilator, and the acetabulum exposed and cleared from the layer of capsule which may cover it. The acetabulum must be deepened, if necessary, by a curette or Doyen's excavator sufficiently to form a cavity to receive the head, with a projecting and well-notched upper border. The head of the femur, if abnormal in shape, must be rounded, but the removal of cartilage from both femur and acetabulum is likely to favor ankylosis. The head of the femur should then be returned to the acetabulum, and the redundant capsule closed by stitches, leaving only a gutta-percha wick, or the whole wound may be packed. The choice will depend upon the surgeon's confidence in his antisepsis. The former course is shorter, and at the Children's Hospital is the one usually adopted. The joint is then fixed in a position of strong abduction by a plaster-of-Paris spica bandage reaching from the axillæ to the toes. At subsequent bandaging the abduction is diminished, and with complete healing of the wound and time for restitution of the divided tissues to normal, massage and passive and active exercises are begun.

Prognosis after Operation.—The statistics of the operation vary so widely that it is difficult to judge what the chances of recovery may be from groups of figures. The figures of the Children's Hospital, Boston, may perhaps be taken as representative of the operation as it stands in this community, taking into account hospital patients.[72]

The series runs from 1884 to the end of 1903, divided into groups—

(*a*) From 1884–1896 (inclusive), 21 cases, all unsuccessful.	
(*b*) From 1896–1902 (inclusive), 54 cases.	
By manipulation, 20 cases:	
Successful	1
Unsuccessful	7
Result unknown	12
By incision, 34 cases:	
Successful	11
Unsuccessful	6
Result unknown	17
Cases operated on in 1902:	
By manipulation, 20 cases:	
Successful	8
Unsuccessful	5
Anterior transposition	7
By incision, 2 cases:	
Both unsuccessful.	
Cases operated on in 1903:	
By manipulation, 24 cases:	
Successful	16
Unsuccessful	3
Transposition	5
By manipulation and machine, 8 cases:	
Successful	6
Unsuccessful	1
Transposition	1
By incision, 1 case:	
Unsuccessful.	

That is to say, of 32 cases in out-patients from two to thirteen, 22 cases (62½ per cent.) were successfully reduced by manipulation (anatomic reduction is meant), 5 of the total number being twelve or over. Five of the cases were bilateral and all were successful. Lorenz[73] reports in 364 cases 52.6 per cent. of good anatomic results. Hoffa obtained in 250 cases (by the bloodless operation of unilateral dislocation) real anatomic restoration in 75 cases (30 per cent.), so that the children walked normally. In 160 cases (64 per cent.) anterior transposition with improvement of gait was secured. In 65 bilateral cases operated on by the bloodless method Hoffa secured 5 perfect anatomic results (7.77 per cent.), in 32 cases (50 per cent.) anterior transposition, and in 10 cases (15.3 per cent.) a good result on one side. By the use of the open operation following or combined with the bloodless method Hoffa "succeeded in curing about 80 per cent. of all cases of congenital dislocation."

Of 22 cases operated on by Lorenz in America and seen and reported by Ridlon[75] there were 26 dislocated hips. The end results showed 12 anterior transpositions:

4 Supracotyloid displacements.
7 Failures.
1 Apparent replacement.
2 Perfect replacements.

Accidents occurred in these 22 patients as follows:

1 Torn perineum.
1 Paralysis.
1 Fracture of the neck of the femur.
1 Fracture of the shaft of the femur.

The percentage of recovery of 62½ per cent. from the Children's Hospital probably represents the status of the bloodless operation at present. The figures from the hospital do not correctly represent the operation by incision, because it has been used of late only after the bloodless operation had failed or in unusually difficult cases.

Choice of Operation.—With proper aseptic technic there is probably little if any greater danger in the cutting operation than in the other. In Hoffa's last hundred operations by the open method there were no deaths.

The bloodless operation is to be undertaken first in children between two and five, when the conditions for it are most favorable. It is likely to be successful from five to ten or even to thirteen, but less likely than at the earlier age. The operation by incision should be done when reduction by the bloodless operation cannot be obtained by the use of reasonable force, when relapse follows that operation, and in cases where there is reason to expect unusual difficulty beforehand. The general opinion is that the operation should not be undertaken before the age of two years, although the opposite has been advocated.

Osteotomy may be necessary after successful reduction on account of the twist in the neck of the femur, which causes a twist in the axis of the leg. In such cases a linear subtrochanteric osteotomy may be performed, or, if the stability of the joint is questionable and the jar of the blows on the chisel is to be feared, the femur may be divided by a Gigli saw.

Congenital Dislocation of the Knee.—Although a rare affection, this is one of the more common of congenital luxations, the usual form seen being the forward displacement of the tibia on the femur. Apparently there are two forms of the affection to be recognized—one a congenital genu recurvatum, not a true dislocation, but a hyperextension of the knee on the thigh without marked displacement of the tibia on the femur. The second is a true dislocation, the condyles of the femur being displaced backward in their relation to the tibia. Of 127 cases collected by Drehmann, 54 were unilateral and 44 bilateral.

The *pathologic changes* are not extreme. The capsule is lax, and the muscles respectively stretched and shortened; the condyles of the femur are small, and the patella often displaced or absent; the crucial ligaments are stretched, and the joint structures may be abnormal. The internal semilunar cartilages were absent in a case of Reiner's. The lower end of the femur has been reported as curved forward on the shaft.

The **symptoms** of the affection are found in the permanent hyperextended position of the knee, a diminution of the hyperextension is resisted slightly, and flexion may be painful. Lateral mobility may be present, and the forward displacement may be associated with some lateral displacement.

The **treatment** of genu recurvatum consists in manipulation into the straight position and the application of a splint. After this, flexion should be secured in the same way. A splint must afterward be worn for a while to prevent hyperextension of the knee. If a true dislocation exists, the child should be anesthetized and the displacement corrected, if possible, by further hyperextension and downward pressure on the foot, followed by flexion, to reduce the tibia to its proper relation with the femur, followed by retention in the proper position. If this is not possible, the method of gradual stretching should be employed, as described.

Operative measures have been followed with some success. The tubercle of the tibia has been transplanted upward to lengthen the extensors, and the tibia held in place temporarily by silver sutures.[81] A supracondylar osteoclasis of the femur has been successfully performed.[82] The articular facets of the tibia have been deepened, and the femur temporarily held in place by sutures.[83] A successful operation has been performed by lengthening the quadriceps femoris and shortening the crucial ligaments.[84]

Posterior dislocation of the tibia on the femur has been recorded, as well as lateral dislocation and mixed varieties.[85]

Congenital Anomalies of the Patella.—Dislocations are extremely rare; outward dislocation is the one most often seen, but upward and inward dislocations have been reported (50[86] outward, 4 upward, 1 inward, Potel). The affection is slightly more frequently single than double (31[87] double, 14 right, 14 left, Zesas). In connection with the outward dislocation, knock-knee may be associated with perhaps flattening of the external condyle of the femur. The disability may be slight or severe, according to the degree of the dislocation, which is often incomplete.

The operative treatment would not differ essentially from that of slipping patella or similar acquired malpositions.

Absence of the Patella.—The patella may be absent, tardy, or imperfect in its development, and the deformity may affect one or both sides. It may be associated with other malformations, especially congenital dislocation of the knee. The treatment consists in development of the extensor muscles and mechanic support to the severer cases.[88]

Congenital Dislocation of the Ankle.—Dislocations inward and outward have been recorded in connection with defective development of the tibia and fibula.

There should be mentioned here "*Volkmann's congenital ankle de-*

formity" (die v. Volkmannschesprunggelenksmissbildung[89]), which is a congenital defect of development in the bones of the leg, with a normal foot, in which the ankle-joint lies obliquely and causes a deformity of the foot, generally in the valgus position, but in one case in a varus position.[90] The condition is to be treated by supramalleolar osteotomy.

Congenital Dislocation of the Shoulder.—True congenital dislocation of the shoulder is extremely rare, very many of the reported cases being paralytic or traumatic at birth.

The dislocation may be subspinous, subcoracoid, or subacromial, and may be single or double. It may be associated with defective formation of the joint, as in a case of Smith's, where the glenoid cavity was practically wanting.

Reposition may be attempted under ether, with subsequent fixation, and if this fails, the joint should be opened and an attempt made to hold the bone in place. This has been accomplished by performing what amounts to an arthrodesis,[93] and by making a new joint (Phelps and Marpon).[1, p. 474]

Fig. 432.—Right Elbow, showing Anterior Dislocation of Head of Radius, Elongation of Radius, and Fusion of Radius and Ulna (Blodgett).

Congenital Dislocation of the Elbow.—Congenital dislocations of the elbow are so rare as to possess but little practical importance.

Two *luxations of both bones* forward have been recorded in two sisters, and one luxation backward.[1, p. 489]

Dislocation of the Head of the Radius.[96]—The luxation of the head of the radius alone is more frequent, 51 cases having been reported. It may be single or double, and occurs oftenest in males. Forward and backward displacements are most frequent, with outward positions more rare. These have been described both with and without abnormality of the other bones of the arm, which occur in about half of the cases.

Elongation of the upper end of the radius is noted in three-quarters of the cases of the three types. Bone fusion of the upper parts of the radius and ulna occurs frequently, and some deformity elsewhere, notably deficiency of the radius or ulna, is found in nearly half of the cases.

Supination and extension are the motions most generally limited, and mobility may be a good deal restricted or fairly free, especially in outward luxations. If the function is very imperfect, the head of the radius should be excised.

Cubitus Valgus and Varus.—The conditions known as cubitus valgus and cubitus varus may be mentioned in this connection, although not congenital dislocations.

Cubitus Valgus.—In cases in which the normal deviation of the forearm outward on the arm is excessive, it is to be regarded as a pathologic condition. It is attributed to hyperextension of the forearm due to laxity of the ligaments, and it is seen in its most marked forms as the result of trauma, and occurs in rickets at times. The influence of heredity is often to be noted.

Cubitus varus is a displacement of the forearm to the ulnar side, making with the arm an angle opening inward. The deformity is most often the result of fractures of the elbow.

If either deformity is severe enough, it should be operated on by an osteotomy of the lower end of the shaft of the humerus.

Congenital Dislocation of the Wrist.—This deformity is exceedingly rare, but cases have been reported of double dislocations in one form of which the hand was held flexed at a right angle to the forearm, which was imperfectly developed. In the other form the hand was hyperextended to a smaller angle. The commoner malformation at the wrist described as club-hand will comprise the remaining cases.

Madelung's Spontaneous Luxation of the Wrist.—Carpus curvus (Delbet). French, courbure rachitique de l'extrémité inférieure du radius. German, die spontane Subluxation des Handgelenkes. This deformity consists in a palmar displacement of the hand, associated with a dorsal prominence of the head of the ulna. The condition is rare, and is seen mostly in women (32 in women, 8 in men, of 40 reported cases) between fifteen and twenty-five. It is as frequently double as single. The causes are apparently to be found in heredity and slight traumatisms; the immediate cause of the deformity was supposed by Madelung to be found in a retarded growth of the joint; rarefying osteitis and late rickets[102] are other causes assigned. The lower third of the radius is found to be curved, with the convexity on the dorsal side, and the function of the hand is most disturbed in the direction of rotation and hyperextension, which is painful, while flexion may be increased. Reposition of the hand is possible only in the slighter grades, and pain is a common symptom.

Massage and hyperextension of the hand by means of splints may first be tried, followed by osteotomy of the radius in resistant or severe cases. Tenotomy of the flexor tendons is not of value.

CLUB-FOOT.

Synonyms.—Talipes equinovarus; pes equinovarus and sometimes pes varus; reel foot. German, Klumpfuss. French, pied bot. Ital., piede varo.

Club-foot is a deformity characterized by inversion of the sole, elevation of the heel, and a torsion and adduction of the front part of the foot.

The deformity in its typical and most frequent form is congenital, but an acquired form is a frequent result of infantile paralysis.

FIG. 433.—PHOTOGRAPH OF SOLE OF CAST OF CLUB-FOOT.

Congenital Club-foot.—The deformity is a fairly common one. In 6969 orthopedic outpatients of the Children's Hospital, Boston, there were 488 cases of congenital club-foot.

It is more often double than single (56.8 per cent. to 43.2 per cent.), and affects males somewhat more frequently than females. In unilateral cases the right and left foot are deformed in approximately the same percentage.

Etiology.—Of the cause of club-foot we know very little, and the fact that about one-tenth of these cases are associated with other deformities, such as spina bifida, hydrocephalus, and similar malformations, makes it plain that in many cases, at least, we cannot account for the cause of club-foot any better than we can for malformations in general. Heredity is an undoubted factor in some cases. There are two distinct classes, however, to be recognized:

FIG. 434.—RELAPSED RESISTANT CLUB-FOOT IN BOY OF EIGHT (Bradford and Lovett).

The first is associated with some malformation of the bones of the foot, such as absence of the scaphoid, defect of the tibia, fusion of several tarsal bones, and the like.

The second and far larger class, however, consists of cases without such defects, and to account for these many theories have been formulated.

Aside from the cases obviously caused by intra-uterine pressure, we can account for the deformity only as we account for deformities in general.

Fig. 435.—Incomplete Club-foot.

Pathology.—The pathologic changes, as a whole, produce a deformed position of the foot resulting in sharp adduction and plantar flexion at the tarsal joints, and a supination of the foot at Chopart's joint. As a result of these the heel is small and elevated, the dorsum of the foot is prominent, and the outer border, and even the dorsum in extreme cases, bears the weight in walking; the sole of the foot is contracted and faces inward, and the foot is bent sharply in and twisted at the tarsal joints. All the bones are changed in shape, and the inner and lower soft parts are contracted and the outer and upper lengthened.

The distortion of certain individual bones is of importance. The astragalus is the seat of the most important changes. It is tipped downward at its front end, and its posterior part articulates with the tibia, its anterior articular surface projecting under the skin. Its neck is elongated and bent inward and downward, so that its scaphoid articulation faces inward and downward and not forward. This is the most important change in club-foot, because the anterior end of the astragalus, the head of the bone, carries inward and downward with it the scaphoid, the three cuneiforms, and the inner three metatarsals. The scaphoid articulates with the inner side rather than the front of the astragalus, and in extreme cases forms a joint surface with the inner malleolus. In shape it may be somewhat changed, being flattened and drawn inward and upward. The os calcis is modified in most important directions. It is generally poorly developed, and its front end

Fig. 436.—Double Club-foot, Moderate Degree (Bradford and Lovett).

is rotated downward and bent inward; the outer surface of the bone is more convex and the inner more concave than normal. Since the anterior facet looks inward and downward, it carries with it the cuboid and the two external metatarsals.

The changes in the other bones are not extreme and not of great importance, the obstacles to reduction lying chiefly in the os calcis and the astragalus.

Soft Parts.—The muscles, ligaments, tendons, and fasciæ at the lower and inner side of the foot are shortened and lengthened at the outer and upper side. The plantar fascia being one of the chief obstacles to reduction, the tendons are displaced, especially those on the inner side of the foot. Evidence of pathologic change in the nerves or spinal cord has been found in some cases, pointing to the occasional occurrence of a form of congenital club-foot of nervous origin.

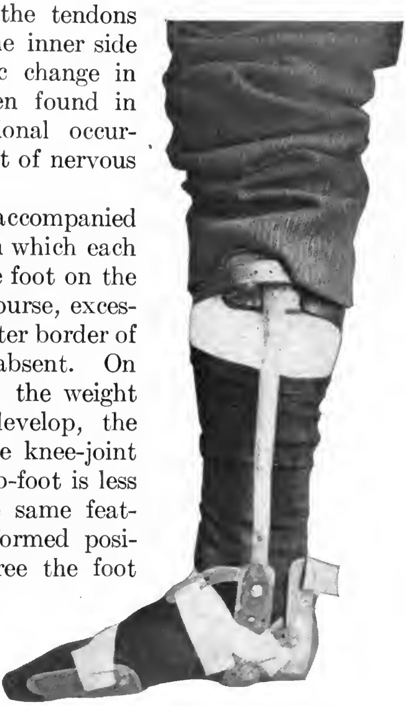
FIG. 437.—CLUB-FOOT; RETENTION SHOE APPLIED (Bradford and Lovett).

Symptoms.—Double club-foot is accompanied by an awkward and unsteady gait, in which each foot is in turn lifted high to clear the foot on the ground, and the "toeing in" is, of course, excessive. The weight is borne on the outer border of the foot, and all elasticity of gait is absent. On the outer border of the foot, where the weight is borne, callosities and bursæ develop, the calves are small, and a laxity of the knee-joint may exist. The gait in single club-foot is less awkward, but characterized by the same features. The foot is rigid in the deformed position, and in cases of marked degree the foot cannot be manipulated into the normal position.

Diagnosis.—Congenital club-foot is not to be mistaken for any other condition. In new-born children there is frequently a tendency to supination of the foot.

Prognosis.—The affection is not self-limited and time tends only to make the deformity more resistant. Spontaneous cure or improvement does not occur. Proper treatment will cure the affection in children and improve the deformity even in severe adult cases. The tendency to relapse is strong throughout childhood, and is almost certain after correction in children by tenotomy, manipulation, or incision, unless the foot is retained for years in an overcorrected position.

Treatment.—The object of treatment should be to restore the foot to, and to hold it in, the overcorrected position during the growing period. In infants an entirely different class of measures will be required from those necessary in older children and adults. In general terms the mildest measure that will overcorrect the position of the individual foot is the one to be chosen.

In the following measures of treatment to be recommended, in a general way the mildest are mentioned first and the severest last, but it must be remembered that two or more of the measures often must be combined.

The earlier that treatment is begun, the more yielding are the tissues, and the quicker is the result. The treatment should be instituted, if possible, when the child is two or three weeks old.

1. *Frequent Gentle Manipulation.*—This treatment, which is able to secure a cure in many cases in infants, can be carried out only with patients of at least average intelligence. The foot is gently and firmly held by the fingers of one hand grasping the dorsum of the foot and the other holding the leg, and the foot is dorsally-flexed and everted, with the outer border of the sole held highest. This manipulation should not be

FIG. 438.—DIVISION OF TENDO ACHILLIS IN CLUB-FOOT.

rough enough to make the child cry, and should be repeated two or three times daily, several times at each sitting. When the foot can be placed in the overcorrected position by the use of gentle force, it must be retained there by some of the appliances to be described later.

2. *Retention of the Foot in an Improved Position.—Plaster-of-Paris.*—This is not only a means of correction, but is the post-operative treatment of all cases. As a means of correction it is applicable to infants, in whom a somewhat corrected position can be obtained, and held by the application of a plaster-of-Paris bandage snugly applied over cotton rollers. This is worn for two or three weeks, and subsequent bandages applied until the desired position has been obtained.

Taylor's Varus Shoe.—The mechanic appliance most likely to be of use is the Taylor club-foot shoe (Fig. 437). Forms of retentive apparatus attached to the outside of the boot are generally inefficient.

3. *Subcutaneous Division of Tendons, Ligaments, and Muscles.*—In case the forms of treatment mentioned above are insufficient; in cases

where it is desired to save time; and in the case of older children, the process of overcorrection will require a division of the soft parts.

The tissues requiring division are most often the tendo Achillis, the plantar fascia, and the soft tissues at the inner and lower side of the foot.

The tendo Achillis is cut by a narrow, sharp-pointed tenotome where it is narrowest, a short distance above its insertion. The foot is then dorsally flexed.

The plantar fascia is divided by inserting a sharp tenotome at its inner border at about the middle of the foot, and thrusting it with the blade parallel to the skin across the fascia. The cutting edge is then turned inward, and the resisting parts divided by a rather deep cut. If resisting bands are left, the process should be repeated.

FIG. 439.—DIVISION OF PLANTAR FASCIA.

The astragaloscaphoid ligament frequently has to be cut[228] to secure abduction of the foot. If other tendons or ligaments are obviously resistant, they should be cut. The wounds should be covered by sterile sheet-wadding rather than gauze, which is apt to cause sloughs, and a retentive plaster bandage applied.

4. *Open Incision.*[229]—The division of the soft parts in the sole and at the inner side of the foot is of value in the more resistant cases, in which the measures above described do not suffice. As originated by Phelps, it consisted in an open incision from the malleolus to the base of the first metatarsal, through which the resistant structures, including the tibialis tendon, were identified and cut. A triangular incision[230] with its apex upward is preferable, as it can be partly closed by sutures and avoid some of the cicatricial contraction inevitably following the original procedure.

5. *The Use of Extreme Force.*—This manipulation requires a separation into the various component factors for correction. Abduction of the forefoot is obtained by bending and bearing down on the foot with

FIG. 440.—FORCIBLE MANIPULATION OF CLUB-FOOT. CORRECTION OF ADDUCTION OF FOOT.

its outer border resting on the apex of a wooden wedge. The rotation of the forefoot is corrected by grasping the forefoot in one hand and the heel in the other, and twisting with the necessary force. The inversion of the sole is remedied in the same way, the wedge of wood serv-

FIG. 441.—PULLING DOWN ASTRAGALUS IN FORCIBLE RECTIFICATION OF CLUB-FOOT.

ing as a fulcrum when required. The tendo Achillis and the plantar fascia are stretched, and dorsal flexion of the foot secured by laying the patient on the face with the knee bent and the front of the thigh resting on the table. The lower leg is then vertical, and by bearing down on the front of the foot with as much force as necessary, dorsal flexion is secured, and by hooking the fingers around the os calcis its position is improved.

FIG. 442.—RESTORATION OF DORSAL FLEXION IN CLUB-FOOT.

Correction of club-foot by instrumental force is accomplished by subjecting the foot to pressure by means of appliances working by screws or levers. These are much the same as the various osteoclasts in principle, and exert any desired amount of force, crushing the foot into shape by tearing ligaments and other soft tissues. They are but little used in America, the one exception being the Thomas wrench (Fig. 443).

In the forcible correction of club-foot by the hands or by instruments the foot is manipulated until it can be held easily in the overcorrected position.

The objections to the method are to be found in its violence and in

FIG. 443.—USE OF MODIFIED THOMAS WRENCH IN CLUB-FOOT.

the severity of the reaction that often follows it. Among the rarer sequels are osteomyelitis, tuberculosis, neuritis, and death from fat embolism, and as a fairly common sequel must be mentioned the occurrence of extensive sloughs from pressure by the bandage and severe swelling.

6. *Operations upon Bone.*[231]—In the case of severe or relapsed club-foot in older children, and in club-foot in adolescents and adults, the operations most likely to be of use are:

1. The removal of a wedge from the outer border of the foot, at the front end of the os calcis, or at its junction with the cuboid. The base of this wedge should be upward and outward, and it is removed after an incision and stripping back of the periosteum to expose the bones. It should be of sufficient size to allow the correction of the adduction and inward rotation of the foot. This procedure in many cases is enough, but in other cases there must be added to it an operation on the astragalus.

2. The neck of the astragalus may be exposed by incision and a wedge of bone removed from it, the base of which should be upward and outward, or in severe cases the whole front part of the astragalus must be removed.

Whatever operation is done, sufficient bone should be removed to permit overcorrection. The removal of too much bone is likely to result in flat-foot.

Tendon transference has been advocated and performed in addition to the measures described in congenital club-foot, a slip of the tendo Achillis or the tendon of the tibialis posticus muscle being united to the peroneal tendons. It is claimed that this tends to prevent relapse. This addition to the operation has not yet been accepted as generally necessary.

Acquired Club-foot.—A position of talipes equinovarus is frequently acquired after birth as the result of paralysis, trauma, and joint disease.

1. **Paralytic.**—Anterior poliomyelitis affecting the muscles at the front and outer side of the lower leg will result in a position similar to that of congenital club-foot. The treatment of them has been discussed in the section on Infantile Paralysis.

Other less common pathologic conditions of the nervous system which cause at times a position of talipes equinovarus are spastic or cerebral paralysis, hereditary ataxia (Friedreich's disease), and progressive muscular atrophy of the peroneal type.

2. **Traumatic.**—A position of the foot resembling club-foot may result from improperly treated fractures of the ankle-joint or tarsal bones. Cicatrices of the inner and lower surfaces of the foot must be mentioned as a possible cause of club-foot.

3. **Cases Connected with Joint Disease.**—In tuberculosis, arthritis deformans, and other diseases of the ankle-joint a position of the foot somewhat like club-foot is at times to be seen as a result of muscular contraction, but pure talipes equinus is more common without a varus element.

Talipes Equinus.—**Synonyms.**—Pes equinus; horse-heel. German, Spitzfuss; Pferdefuss. French, pied bot equin. Italian, piede equino.

Pes equinus is the name applied to the condition in which the foot is held in a position of plantar flexion. The deformity is either congenital or acquired. The latter is the form commonly seen.

Congenital Pes Equinus.—This deformity is not a common one. In some cases it is to be accounted for by intra-uterine pressure. The pathologic changes are those incident to growth in the deformed position.

The treatment consists in manipulation and retention in a plaster-of-Paris bandage in an overcorrected position, which must be obtained by tenotomy of the tendo Achillis if necessary.

Acquired Pes Equinus.—The causes are: (1) Anterior poliomyelitis involving the anterior muscles of the calf, by far the most frequent cause. (2) Spastic (cerebral) paralysis, pseudohypertrophic paralysis, neuritis, and similar affections causing a paralysis or overbalancing of the anterior muscles. (3) Shortening of the leg after injury or disease. (4) Joint disease. (5) Long confinement to bed. (6) Fractures. (7) Hysteria. (8) Posterior cicatrices and injury of the anterior nerves or muscles.

Pathology.—The changes in structure are slight. There are two types of the deformity: in one the whole foot is simply tilted into a position of plantar flexion; in the other, the head of the astragalus is sharply lowered out of its normal relation, and the arch of the foot is much increased.

Symptoms.—The slightest grades of equinus cause hardly more than a slight limp, as the foot cannot be dorsally flexed in finishing each step. Corns and callosities are likely to be developed on the under side of the front of the foot, and the forefoot grows wider. The toes in all grades of equinus are likely to be somewhat clawed. The compensatory form of equinus is not objectionable and makes up for some of the shortening.

The severe forms of equinus may be the source of much disability. In the severest form the foot is so turned that the patient walks on the dorsum of the foot, and in the next grade the weight is borne directly on the heads of the metatarsals.

The diagnosis is easily made by testing the dorsal flexibility of the foot.

The *treatment* consists in subcutaneous division or lengthening of the tendo Achillis by Bayer's method,[234] immediate rectification of the deformity, and retention for three weeks in a plaster-of-Paris bandage in the corrected position In the very severe cases resistant to this method a wedge should be removed from the upper surface of the astragalus or of the tarsus. In case of complete ankylosis of the ankle a supramalleolar osteotomy, or a wedge taken from the front of the joint, may be necessary.

Talipes Cavus.—**Synonyms.**—Pes cavus, excavatus, or arcuatus; hollow foot. German, Hohlfuss. French, pied bot talus; pied creux. Ital., piede cavo; piede plantare.

Pes cavus is the name applied to the condition in which the hollow of the foot is increased. The deformity is rarely congenital, but is frequently seen in its acquired form.

The deformity exists frequently in connection with calcaneus and equinus, especially in their paralytic forms. In its mildest form it exists only as a highly arched foot, often hereditary. It exists also as a shoe deformity, being caused by shoes which are too short.[219] In its extreme form it is seen in the Chinese lady's foot.

Fig. 444.—Pes Calcaneocavus before Operation.

The treatment consists in the subcutaneous or open division of the contracted tissues in the sole of the foot, and a forced redressement into correct position, this position being maintained by plaster-of-Paris.[221]

When the patient begins to walk, it is advisable to have a stiff flat steel plate run the length of the shoe between the leather soles, running from which over the dorsum of the foot is a stout leather strap. At each step downward pressure is thus exerted on the dorsum of the foot.

Talipes Calcaneus. — Synonyms.—Pes calcaneus; pes calcaneus sursum flexus. German, Hakenfuss. French, pied bot calcanien. Ital., piedo calcaneo; piede ad uncino.

Pes calcaneus is the name applied to the condition in which the foot is held in a position of dorsal flexion. The deformity is either congenital or acquired. The latter is the form commonly seen.

Congenital Pes Calcaneus.—This deformity is not common. In some cases the deformity is to be attributed to intra-uterine pressure. The changes in the bone are those produced by growth in the deformed position. The treatment consists in retention in an overcorrected position by a plaster bandage.

Fig. 445.—Talipes Calcaneus.

Acquired Talipes Calcaneus.—The deformity is most often the result of anterior poliomyelitis involving the muscles of the calf. In this connection it is frequently associated with valgus (calcaneovalgus) and frequently with pes cavus. It may also result from chronic disease of the ankle-joint or lower end of the tibia, from rupture of the calf muscles from anterior cicatrices, and very rarely after division of the tendo Achillis. It is also seen in hysteria.

The pathologic changes are those seen from the continuance of the deformity during the years of growth. The patient walks on the heel and the gait lacks elasticity. Reposition of the foot to its normal position may or may not be possible.

PES PLANUS.

Synonyms.—Flat-foot; splay foot; pronated foot; weakened foot; pes valgus; talipes valgus; pes flexus pronatus reflexus. German, Plattfuss. French, pied bot valgus. Ital., pieda piatto; piede valgo.

Flat-foot is a deformity in which the foot is pronated and the forefoot abducted. The loss of the normal height of the arch is a necessary accompaniment of this condition.

The whole terminology of the subject is unsatisfactory. Flat-foot is a term which should really mean a flattened condition of the foot, yet it is used to indicate cases of very slight deviation from the normal which are not obviously flattened. To discriminate between pronated foot and flat-foot, which are only two stages of the same condition, is not practicable, and again to discriminate between flat-foot and pes valgus is making a distinction between two conditions not to be clearly separated.

The term flat-foot will here be used, therefore, to designate all deviation from the normal height of the arch of the foot which are the causes of symptoms, and will be used interchangeably with the terms pes valgus and pes planus.[188]

Flat-foot is either congenital or acquired, the former being one of the less frequent of congenital deformities, and the latter one of the commonest pathologic conditions for which the orthopedic surgeon is consulted.

Congenital Flat-foot.—Congenital flat-foot is a deformity of not very great frequency, and in some cases is associated with defective formation of the bones of the leg.

Symptoms.—The foot of infants is to outward appearances flat on account of a pad of fat under the arch,[190] so that the absence of an arch in no way means congenital flat-foot. In the latter condition the whole foot is displaced outward in relation to the leg, the sole rolled outward, the inner malleolus is prominent, and the foot abducted on itself, and in the severest cases it cannot be replaced in its normal position on account of the contracted tissues.

Treatment.—Manipulation of the foot into a corrected position is useful, and in connection with manipulation, the foot should be held in a corrected position by a plaster-of-Paris bandage renewed at proper intervals, and tenotomy may be required. When the child begins to walk, the arch of the foot should be at first supported by a proper plate.

Acquired Flat-foot.—The common form of acquired flat-foot is the static variety, which is an expression of a disproportion between the body weight and the sustaining power of the muscles and ligaments.

The causes commonly recognized are: 1. The use of shoes of improper shape and size is by all means the most frequent predisposing cause of flat-foot, making all the following causes more efficient and often acting of itself as the sole cause.[193] 2. Weakness and insufficiency of the muscles resulting from poor general condition, advancing age, and convalescence from acute illness, childbirth, and injuries of the leg, especially fractures. 3. Prolonged standing, especially on hard wood and stone floors. 4. Rapid growth. 5. Rapid increase in weight. 6. Excessive weight-bearing, as in the case of jumpers and "strong men." 7. A shortened condition of the gastrocnemius muscle exists frequently as a concomitant of flat-foot, probably partly as a cause and partly as the result of muscular irritability.[195]

Other Forms of Flat-foot.—Aside from the purely static form of flat-foot exist others in which body weight is involved, but is not the sole cause. Such varieties are: 1. From rickets, where a distortion of the bones of the foot occurs. 2. From anterior poliomyelitis affecting the muscles at the inner side of the leg. 3. From spastic paralysis and other disturbances of the muscular system. 4. As a result of inflammation of the ankle-joint, as in tuberculosis and arthritis deformans. 5. As the direct result of Pott's fracture, in which the deformity has not been wholly corrected.

There is apparently no great difference between the sexes, Hoffa finding 217 cases in men and 121 in women, while Blodgett, analyzing 1000 cases seen at the Carney Hospital, found 426 in males and 574 in females.[196] It is much more commonly double than single, two-thirds of Blodgett's cases being double. It occurs most commonly in young adult life, but 4 per cent. of Blodgett's cases applied for treatment after the age of sixty.

Pathology of Acquired Flat-foot.—The pathologic condition found is rather a change of the relations of the bones than any change in the bones themselves. The abnormal position is an exaggeration of the normal yielding of the foot under weight-bearing. The front of the astragalus rotates inward, and with it the bones of the leg, turning at the hip-joint, the deformity being essentially a displacement of the astragalus on the bones of the tarsus.[199] The scaphoid, cuneiform, and the base of the first metatarsal move downward and inward with the head of the astragalus, and the outer border of the foot is made more concave, and the inner becomes convex outward in extreme cases. In the severest cases the head of the astragalus and scaphoid may be displaced below the plan of the other bones. The ligaments and muscles are respectively shortened and stretched in the severest cases, and there is a loss of motion in certain of the tarsal articulations, due to faulty apposition of joint surfaces and constant strain.

Symptoms.—In the adult it is noticed that the feet burn and tire easily, and that, after sitting, they feel stiff and lame. They may swell, and the size of the boots must generally be increased.

After these early symptoms, a painful period generally begins in which walking is avoided, and a dragging pain in the arch and behind the inner malleolus is noticed. This is increased by walking and standing, and tender points may be found under the scaphoid and on the under surface of the heel. The foot feels strained and irritated and is a constant source of discomfort.

Not uncommonly these symptoms take on a very acute type, and a swelled, acutely painful condition of the feet ensues, in which walking becomes impossible.[202]

The inner malleolus is generally more prominent and the foot displaced outward in relation to the leg. The height of the arch is somewhat diminished, may be much lowered, or may be flat on the ground. It must be said, however, that the shape of the foot is not always a safe guide.

When the foot is really flattened, it may be of two types—one the flexible flat-foot, in which the arch can be restored by gentle manipulation, and, second, the rigid foot, which is held by structural changes in the position of deformity; an intermediate class is sometimes seen, where the peroneal spasm is so great that the foot is held abducted and everted by this alone.

Fig. 446.—Flat-foot, Severest on the Left Side (Bradford and Lovett).

Less generally recognized symptoms of flat-foot, which are of great value in diagnosis at times, are corns, ingrowing nails, calluses on the sole of the front of the foot, enlargement of the great toe-joint, hallux valgus, pain in the calves of the legs, especially at night, and a backache aggravated by standing and walking.

Contracted Foot.—A condition was originally described by Shaffer[205] as non-deforming club-foot, in which the dorsal flexion of the foot is limited at or beyond a right angle. The symptoms accompanying this condition are spreading of the forefoot, pain in the calves, backache, and an impairment of the patient's balance, the movements being rather stiff and clumsy. The patients are most frequently young women, often of a neurasthenic tendency. This condition is often hereditary.

Diagnosis.—The recognition of marked flat-foot, whether flexible or rigid, is made chiefly by inspection. The difficulty comes in the lighter cases, which form the bulk of those seen in private practice, in which the changes of form are but slight, and in which the eye of the surgeon must be depended on to detect them.

The symptoms as described must form one's chief reliance in the matter, and the presence of tender points under the arch or heel would confirm the diagnosis of some static trouble. Some help may be obtained from a wet impression of the foot taken on a hardwood floor or paper spread out, but the slighter cases show but little change in the imprint. A more reliable method is to have the patient stand on a glass table with a mirror placed underneath at an angle of 45 degrees, in which may be seen reflected the pressure areas in standing, which show as greenish-white areas. In the most normal feet the outer border of the foot touches the glass, and in pronated feet only two areas bear the weight, one under the inner side of the front of the foot, and one under the inner part of the heel. The information thus obtained is of value only in connection with the clinical symptoms. An x-ray is often of importance as showing the existence of bony changes.

Fig. 447.—Showing Shoe Constriction of Front of Foot with Normal Foot in Shoe Before and after Removing of Upper (Bradford and Lovett).

The diagnosis of rheumatism is frequently made in flat-foot, and is often the source of much misdirected treatment. It should be made only in connection with unmistakable symptoms of rheumatism in the upper extremity. So-called "rheumatic" pains in the knees and hips may be secondary to flat-foot.

Prognosis.—In general the conditions do not favor spontaneous recovery. Under ordinary conditions, uncomplicated cases should be at once relieved by proper treatment, and should be cured in time.

Unfavorable factors in the prognosis are great weight, the coexistence of any degree of neurasthenia, the association of gonorrhea or arthritis deformans, and the presence of bony spurs under the os calcis, as shown in a radiogram.

The prognosis is better in young adults than in persons of advanced age. Patients who have bought and worn without relief the ordinary supports sold at the stores will, as a rule, offer difficulty, and extreme sensitiveness as to the fit of the support is not a favorable prognostic sign.

Treatment.—The foot must be restored to and held in its normal position, and measures must be adopted to quiet local irritability or inflammation and to strengthen the muscles. The best treatment does not consist in the permanent wearing of a flat-foot support; the support should be regarded rather as a temporary expedient to bridge over a painful period, just as one uses crutches in a fracture of the leg.

The Use of Proper Shoes.[207]—As a preliminary to all treatment, the use of a proper shoe should be insisted upon. (1) A shoe should be as wide as the weight-bearing foot in front. (2) The great toe should not be squeezed toward the others by having the inner front corner and border of the shoe cut away. That is, the shoe should have a fairly straight inner front edge. (3) The shank should be fairly wide and not too much cut away at its inner side. (4) The front of the last should not be too thin, but should have room vertically over the metatarsals; otherwise the seam where the vamp is sewed to the upper will draw down upon the arch at each step, and not only tend to lower it, but to cause a "lump" on the dorsum of the foot.[208]

Supports.—The object of a support is to hold the foot in a normal position in order to quiet the irritation of the joints and to rest the muscles behind the malleolus which have been stretched and overloaded by the malposition.

Flexible supports are made of boiler felt or leather reaching from the front of the heel to the base of the great toe-joint at the inner border, and to the outer border of the foot where they are widest. Each support should form half of a dome, the highest point being under the middle of the inner border of the foot, from which point it slopes off in all directions. Such flexible supports should be sewed to an inner sole fitting the shoe. The objection to them is that the shank of the boot and the leather at the inner side soon stretch and yield, and the support loses its efficiency.

They are suitable for use in young children, in slight cases, and in convalescent cases where it is desirable to have the patient use a flexible instead of a stiff support in order to exercise the muscles.

Rigid supports are best made of spring tempered steel (gage 18 to 20), forged hot to fit a cast of the foot furnished by the surgeon. For use they should be copper plated and then nickel plated or covered with leather. They may also be galvanized, which is a more durable finish, but may impair the temper of the steel. They are also made of phosphor-bronze, which, however, is heavy and yields under weight, but can be changed in shape without heating. Celluloid may be used, but is thicker than steel and takes up room.[210]

The shape of plates is a matter of individual judgment.[211] The easiest way to determine the matter is to have the patient stand with the surgeon's hand under the inner border of the foot. The surgeon then places the foot in the normal position, and notes where the pressure must be applied to secure this correction. When the anterior part of the foot is flattened, a slight dome must be raised in the front of the plate. When the os calcis is clearly tilted over, the plate must have two flanges at the heel to hold it in place.

In general the plate must reach forward to a point just behind the great toe-joint, and although it may not extend to the back of the boot, it must furnish support back to the front of the heel. As a rule, plates should be higher inside than outside, and some form of inner flange is generally necessary. An outer flange prevents the slipping of the foot off of the outer side of the plate.

When there is reason to believe that the foot no longer requires support, the plates should be discontinued gradually.

FIG. 448.—VARIOUS PATTERNS OF FLAT-FOOT PLATES ALONE AND INCORPORATED IN LEATHER SOLES.

The Thomas Sole.—The Thomas method of treatment consists in making the inner side of the sole and heel one-eighth or one-fourth of an inch thicker than the outer side, thus securing a slightly inverted position of the sole. So far as it goes it is useful, but the foot slips onto the outer side of the shoe and corns and discomfort are likely to result. The method is of use in some slight cases, and sometimes as an addition to treatment by supports.

Measures to diminish the local irritability and inflammation consist of soaking in hot water, alternating hot and cold douches, massage, hot air, etc., and are an indispensable part of the treatment in irritable cases.

Exercise to the deficient muscles should form part of the routine in most cases of flexible flat-foot.

Braces.—In the severest cases of flexible flat-foot there is so great a downward and inward thrust of the scaphoid and neighboring bones onto the plate that the skin cannot endure the pressure. In such cases an upright jointed at the ankle is fastened to the sole of the boot, and carried up to the upper third of the calf, where it rests by a pad against its outer surface. A T-strap is then fastened on the inner part of the lower surface of the sole of the boot, just in front of the heel, and runs up to the level of the inner malleolus, where the transverse straps pass around to hold the inner malleolus out to the upright. In this way much weight is taken off of the plate.

General Condition.—If neurasthenia, arthritis deformans, gonorrhea, muscular debility, or any similar complication is present, it must, of course, be treated simultaneously.

Treatment of Rigid Flat-foot.—No treatment can obviously be effective until the foot can be placed in the correct position. The patient should be etherized and the foot forcibly manipulated into the correct position by a process of forcible manipulation similar to, but the reverse of, that

FIG. 449.—FORCIBLE CORRECTION OF FLAT-FOOT.

described in speaking of club-foot; after the operation the foot is placed in plaster in a position of adduction and inversion for three weeks. After this a plate should be worn; the results of the operation are generally satisfactory in properly selected cases.

Operative Treatment of Flat-foot.—In the cases which have resisted forcible corrective measures a cutting operation may be necessary. The generally accepted operation consists in a removal of a wedge of bone with the base downward and inward at the point of greatest inward convexity, that is, in the neighborhood of the head of the astragalus. At other times an osteotomy of the front of the os calcis and neck of the astragalus may suffice.

The very many operations proposed for the cure of flat-foot may be found in the reference. In general it may be said that tenotomy, tendon transplantation and shortening, supramalleolar osteotomy, and the various bone operations described will rarely be found necessary.

HAMMER-TOE.

Synonyms.—German, Hammerzehe. French, orteil en marteau.

The name hammer-toe is given to the upward prominence of a toe, generally the second or third.

This toe is hyperextended in its proximal phalanx and flexed in its second one, so that the end of the toe bears on the ground, while the junction between the phalanges makes a prominence upward. Corns and callosities may develop on the end of the toe, but the chief discomfort is in the corns and inflammation which result on the interphalangeal joint which presses against the upper of the boot.

The condition may be congenital, but is more often acquired, in most cases being a shoe deformity in which the toe is crowded up by too narrow or too short a boot.

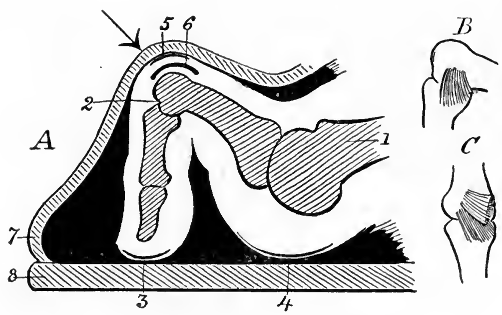

Fig. 450.—Hammer-toe.

A, A diagram of the position of lines in hammer-toe: 1, Metatarsal line; 2, head of the first phalanx; slight groove corresponding to position of dorsal border of second phalanx; 3, 4, 5, callosities due to boot pressure; 6, bursa over contracted joint; 7, 8, shoe (the arrow indicates the direction in which the pressure of the upper leather tends to force downward the head of the metatarsal line toward the sole). B, Dissection of first interphalangeal joint in hammer-toe. C, The same preparation after section of plantar fibers of lateral ligaments (Anderson).

The treatment consists, in young persons, in cases of moderate severity in strapping the toe to a plantar splint. Relapse is likely, and after treatment care must be exercised in the use of a shoe of sufficient width and length. In the severer cases and in relapsed ones the tendons and contracted fascia beneath the toe should be divided by a tenotome as well as the tendon on top of the toe, if necessary, and a splint applied after the toe has been forcibly stretched.

In severe and resistant cases the prominent interphalangeal joint should be excised, and the bone surfaces adjusted with the toe in a straight line.

It is not advisable to amputate the whole toe when the second toe is involved, because severe hallux valgus is likely to result, as the great toe is easily forced over into the space left.

Other Deformities of the Toes.—**Flexed or Clawed Toes.**—A condition similar to that described in hammer-toe may exist in several or all of the toes, the great toe being least often involved. This occurs most often as the result of improper shoes, but is sometimes the result of paralysis and is frequently seen in connection with what has been described as "contracted foot." It is also to be found often in equinus deformity and in connection with pes cavus. The toes, and especially the small ones, develop painful corns on the prominent interphalangeal joints, and in the case of the small toe, when narrow boots are worn, may become a source of great discomfort.

The treatment does not differ essentially from that of hammer-toe, but boots must often be made with much room in the upper of the shoe to remove the pressure.

The amputation of all the small toes is inadvisable even in extreme cases, as predisposing to hallux valgus and flat-foot.

PAINFUL CONDITIONS ABOUT THE HEEL.

Synonyms.—Talalgie; pternalgie.

Painful heel, sometimes described as "policeman's heel," is the name applied to a tenderness of the under side of the heel.

It is associated with one of three conditions: 1. Spurs running out from the under side of the os calcis may be found in the radiograph. 2. There may be a bursitis of the bursa under the os calcis. 3. It may be associated with flat-foot.

The treatment consists in the use of a metal foot plate depressed under the painful area. In cases of painful spurs from the front of the os calcis, especially when associated with gonorrhea, an incision can be made at the side of the heel and the spurs removed in very resistant cases. In arthritis deformans this is not to be advised.

Postcalcaneal Bursitis.—**Synonyms.**—Achillodynia; achillobursitis.

This condition consists in a tender swelling at the junction of the tendo Achillis and os calcis. It is generally traumatic in origin, being caused by an overuse of the gastrocnemius or pressure from the back of the boot. The use of the calf muscles is painful and the patient walks with the foot everted.

The treatment consists in the use of douches, hot air, and massage, with restricted use of the foot. The back of the boot should be cut away to avoid pressure.

A superficial bursa may become inflamed from pressure of the boot and show similar symptoms of less intensity.

Metatarsalgia.—**Synonyms.**—Morton's disease.[121] German and French, Metatarsalgie.

This name is applied to a condition characterized by an acute cramping pain occurring at the base of the third or fourth toes.

It affects women more often than men, and is frequently seen in persons of a highly developed nervous organization. It may be hereditary, and is rarely, if ever, seen in children.

Etiology.—The cause of the pain seems to be a disturbance in the normal relation between the heads of the metatarsal bones, so that they either pinch the plantar nerves between them or press down upon them.[123]

Symptoms.—The pain in this affection comes on suddenly during the use of the foot and may be very severe. It is often accompanied by a snapping of the bones, or the snapping may exist alone. The patient at once seeks relief by taking off the shoe and rubbing the foot. After the attack a sense of soreness and numbness remains, affecting the toe. The attacks vary in frequency, the tendency being toward an increase in their frequency and severity. The plantar flexion of the toes is generally limited.

Accompanying this condition there may be found one or more of the following conditions: 1. That the foot is normal. 2. That the arch is somewhat lowered. 3. That the front of the foot is relaxed and flattened, a hollow being seen on the dorsum of the forefoot over the heads of the middle metatarsals. 4. That dorsal flexion of the foot is limited.

Diagnosis.—The frequency of the diagnosis of neuralgia makes it necessary to call attention to the perfectly definite and characteristic symptoms of metatarsalgia.

The prognosis has been mentioned and the affection is often obstinate.

Treatment.—If any static deformity of the foot exists, it should, of course, be remedied by supports, as described in flat-foot. If the gastrocnemius muscle is contracted, it should be stretched. If the anterior arch of the foot is depressed, a dome of felt fitted in a leather sole should be placed behind the heads of the metatarsals, or a metal plate with a gradual dome raised to fit in behind the heads of the metatarsals should be worn. This plate may, of course, also support the rest of the foot as desired. Boots of proper width should be worn, to avoid compression of the front of the foot, and the flexibility of the toes increased by exercises in which the toes are bent downward.

The removal of the distal end of one of the metatarsals has been advocated, but is rarely needed if proper mechanic treatment is followed out. This operation has at times been followed by a relapse of symptoms.

HALLUX VALGUS.

Synonyms.—French, déviation latéral du gros orteil. Italian, contrattura di abduzione dell alluce.

Hallux valgus is the name applied to a displacement of the great toe outward (abduction), that is, toward the outer border of the foot.

In the normal foot the line of the great toe when prolonged backward should pass through the center of the heel (Meyer's line). This relation of the great toe in civilized communities is seen only in the feet of infants. In adults the normal position of the great toe is found only among bare-footed races; only when it reaches a degree serious enough to give rise to trouble is it considered pathologic. In this sense it is essentially a deformity of adult life.

Etiology.—The cause of hallux valgus is to be found in the wearing of shoes and stockings. Hallux valgus is frequently associated with flat-foot, probably both as a cause and a result, and associated with hallux valgus are often to be found gout and arthritis deformans.

Pathology.—The displacement outward (which reaches from 30 to 40 degrees in average cases, may reach in some cases 90 degrees) of the phalangeal part of the great toe-joint uncovers the inner part of the head of the metatarsal bone, and here the cartilage degenerates and the bone becomes condensed at its outer part. Between the normal part of the joint and the diseased part is to be found a furrow spoken of as the sagittal furrow of Kenbach. The inner lateral ligament is lengthened and hypertrophied, and the sesamoid bones displaced outward and often hypertrophied. Under the skin at the inner and prominent aspect of the foot is to be found a bursa, which is liable to inflammation under pressure, known as a bunion. The inflammation in this sac may extend to the joint and disintegrate it.

Symptoms.—In hallux valgus the toe is displaced outward, and a

B A

FIG. 451.—A, PHOTOGRAPH OF PLASTER CAST OF FOOT OF BAGOBO BOY THAT HAD WORN SHOES A FEW MONTHS, CONTRASTED WITH B, PHOTOGRAPH OF AN ADULT BAGOBO THAT HAD NEVER WORN SHOES (Hoffmann).

reddened and shiny condition of the thickened skin exists over the inner prominence and perhaps the top of the toe-joint. The great toe, if seriously displaced, must lie over or under the outer toes, the former being the more common position. In other cases the second toe may be crowded up as a hammer-toe. The joint is painful, and the inner toes being crowded to the outer side of the foot, are the seat of corns and callosities. Flat-foot is frequently associated.

The diagnosis is evident from the description, and the prognosis is that under unchanged conditions the deformity will progressively increase.

Treatment.—In the mildest cases the stocking should be split to allow a separate stall for the great toe, and boots allowing room for the great toe should be worn. If any degree of flat-foot coexists, a support should be applied which will help to restore the position of the great toe. In the next grade of cases a toe post should be used.[207]

Fig. 452.—A Predominant Type of Footwear and its Inevitable Effect. The shape of the foot conforms to that of the shoe (Hoffmann).

Operative Treatment.—In the severe cases nothing short of operation is likely to be of value.

An incision is made on the upper and inner aspect of the joint, the bones exposed, and a wedge with the base outward removed from the head of the first metatarsal bone, or the whole joint is resected, the ends

Fig. 453.—Hallux Valgus.

of the bones being cut so that their apposition leads to a proper position of the toe. Wiring is not necessary, and a firm union results which prevents relapse. The inner edge of the metatarsal head should be cut off if it projects.

Another operation consists in the removal of the projecting inner surfaces of bone at the metatarsophalangeal joint[276] by the use of a

FIG. 454.—HALLUX VALGUS.

saw or bone forceps. The contour of the foot is thus restored without the destruction of the great toe-joint.

HALLUX VARUS.

Synonym.—Pigeon-toe.

This name is applied to an inward deviation (adduction) of the great toe. It is essentially a disease of infancy and young children. It exists as a congenital deformity; it accompanies club-foot, is seen after knock-knee of long standing in which the forefoot reaches in toward the middle line of the body to obtain a more stable support, and in congenital pes valgus which accompanies a defect in the fibula. The treatment consists in bandaging the toe to the others if the deformity is severe enough to warrant it; otherwise the wearing of an ordinary boot will be sufficient.

DUPUYTREN'S CONTRACTION OF THE FINGERS.

Synonyms.—Dupuytren's contraction. German, die Dupuytrensche Contractur der Finger. French, la maladie de Dupuytren; la contraction des doigts (Dupuytren).

Dupuytren's contraction is the name applied to a permanent flexion of one or more fingers, due to a contraction of the palmar aponeurosis and its digital prolongations.

Although the deformity was described as early as 1610 by Plater,

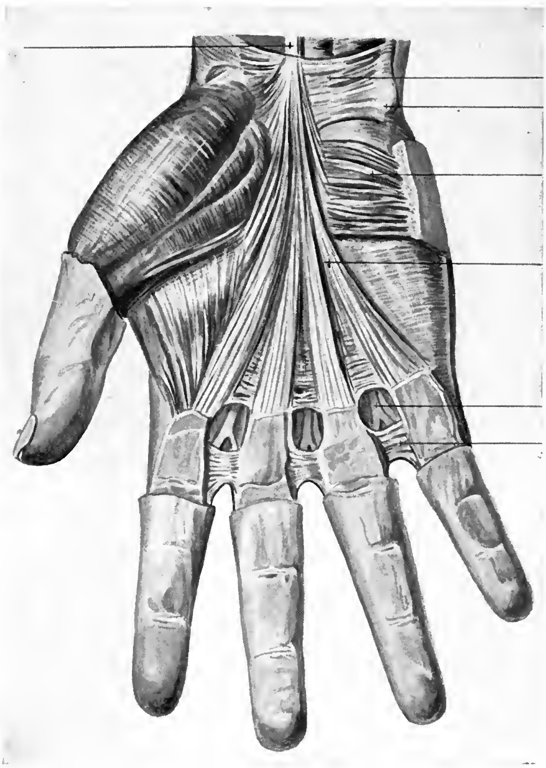

Fig. 455.—Dissection of the Palmar Fascia (Spalteholz).

and by other writers subsequently, it was Dupuytren who identified the true nature of the condition and discovered that it was not an affection of the tendons, but of the palmar aponeurosis.[148]

Surgical Anatomy.—The palmar fascia, which is the seat of the affection, is divided into three parts. One lateral part covers the thenar eminence and the other lateral part the hypothenar; these are comparatively thin, and, extending around the borders of the hand, become continuous with the dorsal fascia. The middle and important part of the fascia is thicker, and in part originates from the palmaris longus muscle, and in part from the anterior annular ligament. It spreads out like a fan from the wrist downward, and divides into four slips, one for each finger. These slips pass down in the median line of each finger, and each divides at the base of the finger into three smaller processes. The median one of these passes along the palmar surface of the finger, to be inserted into the skin as far down as the pulp of the last phalanx; the two lateral processes surround the tendon sheaths and are inserted into the dorsal surface of the first and second phalanges. The anterior surface of the fascia throughout is attached to the skin by small fibrous prolongations. The skin is thus closely adherent throughout. The function of the palmar fascia is to protect the vessels and nerves in the palm of the hand, to prevent hyperextension of the fingers, and to preserve the hollow of the hand.

Pathologic Anatomy.—The changes in Dupuytren's contraction consist of a chronic hyperplastic inflammation of the palmar fascia. This affects chiefly the longitudinal bands and begins locally, most often at a point opposite the metacarpophalangeal joint. The characteristic lumps in the palm appear at this region opposite the finger to be drawn down, and are the first recognizable change. Microscopically, the diseased tissue consists of bundles of dense white fibrous tissue with fusiform connective-tissue cells and small vascular channels, but later the vascularity diminishes, and a denser scar formation takes place, involving palmar fascia and adjacent connective tissue and fatty structures. The skin, tendons, and articulations of the fingers are only involved secondarily, and the last two only in cases of very long standing. In the severest cases the affected finger-joints have been found ankylosed. An exostosis on the dorsal portion under the joint surface of the metacarpus is described as sometimes existing.[150]

Occurrence and Etiology.—*Sex.*—In 227 cases there were 180 men and 40 women.

Heredity was noted as a factor in 50 out of 198 cases.

Location.—In 223 cases (Keen and Nichols) the right hand alone was involved in 70, the left in 38, and both in 125.

In 263 cases (Keen and Nichols) 572 fingers were involved as follows:

Thumbs	12
Forefingers	24
Middle fingers	93
Ring fingers	249
Little fingers	194

Frequency.—In 2600 adults of the poorer classes, five-sixths of whom were above middle age, 1.27 per cent. were affected. In 800 children under sixteen, none showed the deformity (Adams). In 1000 ex-soldiers examined by Nichols averaging fifty-three years old, 3.9 per cent. showed the contraction. Of 1444 cases of deformity, Dupuytren's contraction formed 1.59 per cent. (Hoffa).

Age.—The affection is most frequently found in persons above middle age. It has been recorded by Tubby in a girl of sixteen.

Occupation.—In 72 cases tabulated by Keen, 18 only were manual laborers.

Causation.—The cause of Dupuytren's contraction has been discussed for many years and cannot be regarded as settled. The causes assigned are as follows:

1. Trauma.[154]
2. Gout and rheumatism, arthritis deformans, and arteriosclerosis. Syphilis is a probable cause in certain cases.
3. Organic nervous disease.
4. The bacterial origin, as suggested by Anderson, has not been substantiated by microscopic evidence.

The soundest position probably is to assume that the contraction may arise from more than one cause, and that, once started, the trauma of use probably serves as an irritant.

Fig. 456.—Dupuytren's Contraction (Keen).

Symptoms.—The earliest symptoms noted are the appearance of hard knots in the palm of the hand, followed, after a long interval, by inability fully to extend the affected finger or fingers. In one form of the affection the contraction is confined mostly to the palm, which is corrugated and thickened, while in the other form the flexion of the finger is the chief sign. The latter is the one most frequently seen.

From the knots there are formed bands running down to the fingers, which become very prominent when put on the stretch by extending the fingers passively. As the ends of the fascial bands are approximated more and more by the fascial contraction, the finger is flexed first at the metacarpophalangeal joint and then at the first interphalangeal joint, but not at the second joint, which is beyond the insertion of the fascial prolongations.

In extreme cases the finger-tip rests against the palm of the hand, but rarely buries itself in it.

When the process extends to other fingers, this occurs by the formation of new knots in the palm, followed by contracting bands. The skin of the palm is thrown into transverse folds and the usefulness of the hand is impaired. The process is slow and not particularly painful, although there may be associated neuralgia, and it is generally more advanced in one hand than in the other when both are involved.

The diagnostic signs are the presence of the knots in the palm, the freedom of the tendons, the possibility of flexing the finger-joints, and the absence of flexion in the joint between the second and third phalanges, coexisting with a slowly increasing flexion deformity of the ulnar fingers in a patient past middle age.

The prognosis is for a slow increase of the deformity, with probable involvement of other fingers.

Treatment.—It is unlikely that the progress of the deformity is to be markedly retarded or arrested by the use of massage or splints. Subcutaneous divisions of the fascial bands, either single or multiple, as advocated by Adams,[190] the open division of the skin and band together, the V-shaped incision of Busch, and similar methods which were necessary before the advent of aseptic surgery, are today not to be recommended, as with our present knowledge of the affection we must recognize their inadequacy. If used, they must be regarded as incomplete. The rational measure is, of course, the excision of the contracted band or bands.

Fig. 457.—Dupuytren's Contraction (Adams).

The operation of Kocher[163] is in general use, and may be performed under general anesthesia, by the subcutaneous injection of cocain, or, as in a case reported by Keen,[165] by the exposure of the median and ulnar nerves at the wrist and their infiltration with a solution of cocain. The contracted band is exposed in its entire length by a longitudinal palmar incision, the skin is dissected free from the diseased fascia, and the contracted band extirpated after being carefully dissected out, the dissection including its attachments to the fingers. The wound is sutured and dressed, and a palmar splint holding the fingers in extension is applied. Massage and passive movements should be begun after two weeks.

A more radical method has been advocated[166] and used for the treatment of relapsing or very severe cases. The skin of the whole palm and the palmar fascia are removed by dissection, and the defect filled by a flap from the chest or thigh to which a pedicle is left attached.[167]

When a keloid forms in the scar, it may be removed by a subsequent operation if it resists treatment by the x-ray.

A new operation has been devised by Keen[168] for use in extensive and relapsing cases in which the contracted area is too extensive to be thoroughly removed through the ordinary longitudinal incisions, and the skin is so tightly and extensively adherent to the fascia that it would surely slough if dissected. A U-shaped flap begins at the thenar eminence, runs to the level of the knuckles, where it turns at a right angle toward the ulnar border of the hand, and in the line of the little finger turns again at a right angle to run to the hypothenar eminence, where it terminates. This flap includes skin and palmar fascia. The flap is turned back, and the palmar fascia dissected off, including the prolongations to the fingers; after this the flap is replaced and stitched.

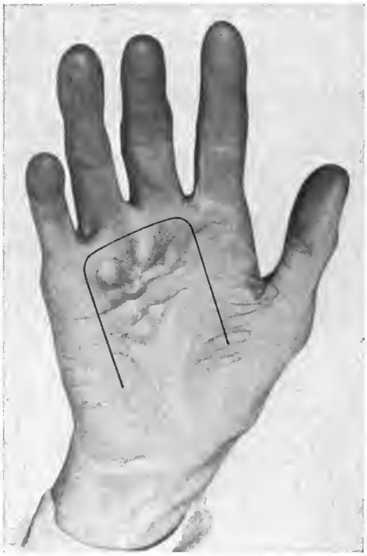
FIG. 458.—INCISION FOR OPERATION FOR DUPUYTREN'S CONTRACTION (Keen).

ANOMALIES OF THE FINGERS.

Trigger=finger. — **Synonyms.** — Lock-finger; snapping finger. German, schnellender Finger. Ital., dito a scatto.

In this affection flexion or extension of the finger is accomplished to a certain point, then the motion ceases temporarily, but with strong muscular effort on the patient's part a snap occurs and the motion is completed; but in severe cases both extreme flexion and extension may be impaired. Pain may or may not accompany the snapping. Very rarely the affection is congenital; more often it is associated with trauma, overuse, gout, and arthritis deformans.

The **pathology** of the condition is varied. Circumscribed tendon thickening, new-growths from the tendon, protuberances on the edges of the joints, a stretched condition of the side bands of the tendon, a narrowing of the tendon sheath, and adhesions in the tendon sheaths have all been established as possible causes.

The **treatment** consists in soothing applications, rest, massage, etc., which will effect a cure in many cases. In resistant cases the tendon sheath should be opened and the obstacle to free motion investigated and removed.

Mallet=finger.—**Synonym.**—Drop-finger.

Mallet-finger is a flexion deformity of the terminal phalanx of the finger caused by a tearing of the extensor tendon at its insertion into the dorsal surface of this phalanx.

The deformity always exists as the result of an accident in which the end of the finger or the nail is struck against some object. The accident may often be surprisingly slight, and, as a result of it, the terminal phalanx drops into a position of more or less flexion, which may amount to only a slight drooping or may reach a right angle with the next phalanx. It cannot be voluntarily extended, but can be passively straightened.

The **treatment** in recent cases should consist in the application of a palmar splint holding the finger extended. If this treatment fails to secure union in a correct position, the site of the tear should be exposed by an incision, and the distal end of the torn extensor tendon united by sutures to the periosteum of the dorsal surface of the base of the phalanx and the finger kept extended by a palmar splint.

Club-hand.—**Synonyms.**—German, Klumphand. French, main bote. Italian, mano torto.

The name club-hand is given to a congenital deviation of the hand from the line of the forearm, which occurs at the wrist. It may occur alone or in connection with deformities elsewhere, among which must be mentioned club-foot.

FIG. 459.—CLUB-HAND (Sayre).

The deformity may occur without defects in the skeleton, or it may be associated with defect of the radius, ulna, or carpus, with which are likely to be associated abnormalities of the soft parts. When the radius is absent, the lower end of the ulna is enlarged.

The deformity is classed clinically as—(1) Palmar, when the hand is flexed; (2) dorsal, when it is extended; (3) radial, when the deflection is to the radial side of the forearm; and (4) ulnar or cubital, when it is to the ulnar side. Mixed forms are to be seen, as the radiopalmar, which is the most frequent when the skeleton is not deficient. In this variety the hand is flexed and resistant to correction, and there may be stiffness of the elbow- and shoulder-joints. If bony defects are present, the deformity may be extreme, and this depends, of course, on the character of the deficiency.

The **treatment** in cases in which the skeleton is normal is similar to that of club-foot, and consists in manipulation and the application of corrective plaster bandages, with the addition of tenotomy or tendon transplantation if necessary. When there is bony deficiency, the treatment consists in operative measures to restore as nearly a normal relation of the bones as possible.

R. H. Sayre[140] corrected the curve of the ulna by osteotomy, and later removed two of the carpal bones and the styloid process of the ulna, and inserted the end of the ulna into the gap left in the carpus. Hoffa[141] and Thomson[142] secured correction by osteotomy of the ulna. McCurdy[143] divided the ulna across and sutured its end to the semilunar bone. Bardenheuer[144] and Romano[145] cut out a cavity in the end of the ulna and put the carpal joint into it. The results of all these operations have been favorable, but it must be remembered that only imperfect function can be expected when serious bony defects are present.

FIG. 460.—SYNDACTYLISM.

Syndactylism.—Synonyms.—Webbed fingers or toes; fusion of the fingers or toes.

The name syndactylism denotes a condition in which two or more of the fingers or toes are united together by their lateral aspects. (1) This union may consist of thin membrane, which is called by the French *main palmé.* (2) The uniting structures may consist of skin which may exist merely as an extension of the normal web. (3) The connection between the two fingers may be a firm structure of skin and fascia fusing the two fingers into one, with perhaps only a single nail for the two. (4) Finally the union may be osseous, generally affecting the terminal phalanges, but also at times causing a fusion of all the bones of two fingers.

FIG. 461.—SYNDACTYLISM—WEBBED FINGERS.

The condition of the bones can be accurately ascertained by the use of the *x*-ray.

Treatment.—In the case of the toes, no operation is necessary. In the fingers, simple division of the web is likely to be followed by a cicatricial band growing up from the bottom of the cleft. Some simple plastic operation which will leave skin surfaces in contact must be performed. If the bones are united, they must be cut apart, and in complete osseous union a result warranting operation is not likely to be obtained.

Of the many operations devised, the best known is that of Didot, a description of which will show the essentials of all the measures described. An incision in the length of the finger is made on the dorsal surface of one finger, from the base of the nail to the bottom of the finger, and transverse incisions are made at the top and bottom of this, which run to the middle of the dorsal surface of the finger, to which it is united. A flap is then dissected as far as the ends of the transverse

FIG. 462.—OSSEOUS SYNDACTYLISM.

FIG. 463.—SYNDACTYLISM, SECOND VARIETY.

incisions. A longitudinal incision is then made on the palmar surface of the other finger, also with transverse cuts and a similar flap. The fingers are then separated and the dorsal flap wrapped around the finger and its edge sewed to the palmar incision. A similar procedure with the other flap covers each finger at its point of contact with a skin flap.

Polydactylism (*Supernumerary Fingers*).—The name of this de-

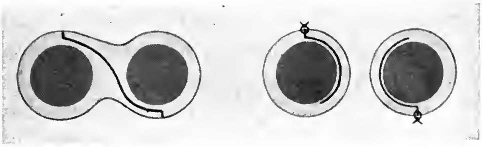

FIG. 464.—DIAGRAM OF DIDOT'S OPERATION FOR WEBBED FINGERS. SECTIONAL VIEW (Fowler).

formity is self-explanatory and designates the most common of such abnormalities. The element of heredity is marked, and the deformity is most often symmetric, and is likely to involve both fingers and toes. The classification of Annandale[137] is generally accepted: 1. A rudimentary digit loosely attached to any part of the hand or foot or to another digit. 2. A more or less developed digit, articulating with the head or side of a metacarpal, metatarsal, or phalangeal bone. 3. A perfect digit, with a metacarpal or metatarsal bone of its own. 4. A digit united in its length to another articulating with a metacarpal or metatarsal bone of its own, or with one shared with another digit.

The **treatment** in the first two classes consists in the removal of the extra digit. In the third and fourth it must be carefully considered whether the scar and the interference with the metacarpus or metatarsus will not be more of a disfigurement than the extra finger. After a careful study of the radiograph each case must be treated according to its individual requirements.

Ectrodactylism.—Congenital deficiencies of the fingers and toes,

FIG. 465.—DIDOT'S OPERATION FOR WEBBED FINGERS (Fowler).

intra-uterine amputations, anomalies of soft parts and bones, bifurcated hands and feet, and the like are congenital deformities of occasional occurrence which are considered at length in books dealing with their especial subjects.

Contractions of the Fingers.—Aside from congenital dislocations of the fingers, side deviations, and similar rare deformities, contraction of the fingers from various causes demands brief consideration.

Congenital contraction of the fingers exists rarely as a flexion of the little finger of one or both hands, with perhaps involvement of the ring-finger or others. The condition is likely to be hereditary, and is most often due to a shortness of skin and fascia on the palmar surface. The correction can generally be made by manipulation and stretching on a splint, but in some cases a plastic operation on the skin may be required.

Contraction of one or more fingers in a flexed position may exist as the result of *scar formation* on the palmar surface of the finger, as the

FIG. 466.—CONGENITAL CONTRACTIONS OF THE FINGER (Hoffa).

result of *inflammation of the tendons* on the palmar surface of the hands or fingers, as the result of *muscular contraction,* as in hemiplegia, or from prolonged fixation, as a sequel of *inflammation of the finger-joints,* as in arthritis deformans, and as a result of *paralysis* of some of the muscles.

THE DEFORMITIES OF RICKETS.*

The softening of the bones incident to the process described as rickets may be generally distributed in the severe cases, affecting arms, legs, pelvis, clavicles, chest, head, and spine, and in each of these localities may be found deformities.

These deformities occur as the result of forces acting upon bones of impaired resistance. The chief factors in causing deformity are—(1) Body weight (or gravity); (2) the pull of attached muscles; (3) pressure and distorting influences from attitude, atmospheric pressure on the chest, and the like. A combination of these exists in many cases.

The rachitic deformities with which the orthopedic surgeon is chiefly concerned are bowleg, knock-knee, lateral curvature of the spine, coxa vara, and deformities of the chest. The latter will be considered under their proper heading. When deformities of the arms are severe enough to require treatment, the principles laid down in regard to the deformities of the legs are to be applied.

Bowlegs.—Synonyms.—Genu varum; genu extorsum; out-knees; bandy-legs. German, Sabelbein; Sichelbein; O Bein. French, genou en dehors. Italian, ginocchio varo.

The term bowlegs is generally applied to an outward curving of the legs, and a forward curve of the tibia is spoken of as anterior bowlegs.

* See Vol. I, p. 580.

Bowlegs, in the general sense, is either a gradual curve of both thigh and leg, a curve of the lower leg alone, or an outward angular deformity of the knee in which the thigh and leg share only slightly.

It is a common deformity in children, and the most frequent bone deformity in rickets. In 12,694 orthopedic out-patients examined at the Children's Hospital, Boston, there were 1807 cases of bowlegs. It is more commonly double than single, and is an affection of early childhood.

Causation.—In children the deformity is almost uniformly due to rickets. In adults it occurs in osteitis deformans, and may occur in osteomalacia. It may occur as the result of improperly united fractures, and in children as the result of injury or disease of the epiphyses of the knee.

Fig. 467.—Bowlegs Affecting Chiefly the Tibia.

Fig. 468.—Bowlegs. Rickets.

Pathology.—The deformity is due to a yielding of the softened bone in the line of least resistance, which, for some reason not clearly formulated, is in most cases outward,[106] in others forward, while in others it is inward at the knee, causing knock-knee. The bend is generally a gradual yielding, but infractions of the bone occur. Changes in the knee-joint are rare. Accompanying the outward bend is a rotation of the tibia turning the foot inward.

Symptoms.—Bowlegs may be noted in children in arms, but generally appears between two and three years. It is evidently not to be attributed to walking too early, but to rickets. The general signs of rickets are in most cases to be detected.

The child stands with the legs apart and the deformity much in evidence; in walking the gait is a waddle, as the patient has to lean over at each step to get the center of gravity over the center of support. Such children toe in and are unsteady in their gait. Pain is rarely complained of. With marked bowlegs some degree of coxa vara generally exists.

Diagnosis.—The diagnosis of bowlegs is evident from inspection.

Prognosis.—Ordinary outward bowlegs of moderate severity may be outgrown without treatment or may persist into adult life. We have not the data to say which is likely to occur in a given case.

With proper treatment outward bowlegs in children can almost invariably be cured by suitable mechanic or operative treatment. In adults the deformity may be improved by operative measures. Anterior bowlegs of more than a slight grade, as a rule, is not benefited by mechanic treatment.

FIG. 469.—BRACE FOR BOWLEGS (Bradford and Lovett).

Treatment.—*Expectant.*—In children under three years old with slight bowlegs, no mechanic treatment is at first necessary. The child should be placed under favorable general conditions, and twice each day the child should sit with the ankles together and the legs should be gently pressed together with the flat of the hands opposite the points of greatest curve.

Mechanic.—Up to four years of age braces running up the inside of the leg and pulling the knee inward should be applied to moderate and severe cases of outward bowlegs, and to slight cases where expectant treatment is inadvisable for any reason.

The treatment of anterior bowlegs by apparatus is not, as a rule, sufficiently satisfactory to make its consideration of value.

Operative.—Operation is indicated in children over four when the deformity is even of moderate grade, although there is still some chance of spontaneous outgrowth. Operation under four is likely to be followed by relapse, as the bones are not, as a rule, sufficiently eburnated.

Two operations are in common use: (1) Osteoclasis, which consists in the fracture of the bone by means of an osteoclast. (2) Osteotomy is to be preferred to osteoclasis in adults, in curves near the joints, and in anterior bowlegs, and a linear osteotomy is to be preferred to the removal of a wedge which shortens the leg. Even in severe curves which are sharply localized the removal of a wedge may generally be avoided by driving the chisel into the bone at the concavity of the curve and opening up the cut bone when the bone is straightened.

Anterior Bowlegs.—This deformity may be corrected either by osteoclasis or osteotomy. In the former the bone is broken from the side at the point of greatest curve, the tendo Achillis cut if necessary, and the leg straightened by manipulation. In osteotomy the bone is cut from behind, the tendo Achillis divided if it offers resistance, and the leg straightened, opening up the linear cut at the back of the bone.

Knock-knee.—Synonyms.—Genu valgum; in-knee; genu intorsum. German, X Bein; Backerbein; Knieng. French, genou en dedans; genou cagneux. Italian, ginnocchio valgo.

The term knock-knee is used to describe an inward prominence of the knee in which the bones of the leg form an angle with each other. This angle opens outward.

Knock-knee of a grade severe enough to require treatment is a common deformity, but less frequently seen in American clinics than bowlegs. In Germany their relation seems reversed.[1, p. 716] At the Children's Hospital, Boston, in 12,694 orthopedic out-patients there were 753 cases of knock-knee as contrasted with 1807 of bowlegs.

The lower end of the outer condyle of the femur projects further down in its relation to the inner than is normal, and the facets on the tibia may show a similar obliquity, but the epiphyseal lines are also oblique and not in their normal relation to the long axis of the bones. The joints are likely to be in a state of subacute inflammation, and joint cartilages, ligaments, and semilunar cartilages show the effect of pressure, being thickened on one side and atrophied on the other in older cases. The tibia is rotated outward on the femur in severe cases and the foot adducted, sometimes into a position of varus, by the effort of the patient to reach in toward the median line for support. The patella is displaced outward, and the relation of the tendons to the bones is disturbed.

The deformity may be single or double, and may exist on one side, while bowlegs is present on the other. Boys are more frequently affected than girls, and the deformity is essentially one of childhood, although occurring at times during adolescence.

Causation.—It is in general a deformity seen in connection with—(1) rickets, but it occurs also (2) at adolescence, when its relation with true rickets has not been firmly established. (3) It is very rarely a congenital condition. (4) It is sometimes the result of trauma following fractures and epiphyseal injury or disease. (5) It occurs in the late history of some cases of inflammatory disease of the knee, chiefly tuberculosis and osteomyelitis. (6) It is to be seen in old cases of anterior poliomyelitis affecting the leg.

Pathology.—Three conditions are found to exist in rachitic knock-knee: (*a*) Where the deformity is manifested almost wholly by an obliquity of the joint surfaces. (*b*) Where there is a marked curve in the lower part of the femur. (*c*) Where there is a marked curve in the upper part of the tibia.

Symptoms.—In children when the deformity is slight the gait is awkward, falls are frequent, and rarely the knees are irritable and painful. In severe cases the gait is most ungainly, as the patient has to swing the free leg out to clear it from the prominent knee of the leg which is bearing the weight. The deformity disappears on flexion of the leg to a right angle, but in this position the inequality in the position of the condyles is clearly to be seen by looking across the lower end of the femur.

When the patient stands with the inner side of the knees in contact, the malleoli are some distance apart. In severe cases, however, the patient learns to stand with the ankles together, which he does by hyperextending one knee and slightly flexing the other, so that the knees overlap slightly. The

Fig. 470.—Slight Knock-knee.

Fig. 471.—Severe Knock-knee.

legs are rotated out on the thighs in the severer cases, and the feet are in a position of mild varus in such cases, which must be reckoned with after the deformity is corrected. Abduction of the legs is generally restricted from the coexistence of coxa vara. Lateral mobility of the knee-joint is generally present.

Diagnosis.—Some degree of knock-knee is anatomic, and more marked in adult women than in men. When a child stands with the knees together and the ankles well apart, he is suffering from some degree of knock-knee.

Prognosis.—Severe cases cannot be expected to correct themselves, but can always be improved by treatment. Moderate cases in young children are amenable to mechanic treatment. Slight cases in rapidly growing children may be cured either by the mild measures used with expectancy or by other treatment. Even the severest cases may be greatly improved by operation.

Treatment.—*Expectant.*—In mild knock-knee in young children the child's leg should be daily manipulated into a straight position with the knee extended, by pressing out on the knee with one hand and in on the leg with the other. Such children should wear some support to hold up the arch of the foot, or have the inner side of the shoes raised one-fourth of an inch by the Thomas method, in order to throw the line of weight further to the inner side. If improvement ensues, nothing more is necessary; if not, mechanic treatment is to be advised.

Mechanic.—Mechanic treatment consists in pulling the knee outward to an upright at the under side of the leg. Such an apparatus must also hold the knee extended, as the deformity is greatest in the extended position. The brace is similar to that described for bowlegs, but, of course, on the outer side of the leg. Mechanic treatment is not likely to be easily successful after the age of four or five.

Fig. 472.—Brace for Knock-knee (Bradford and Lovett).

Operative.—Osteotomy is the operation of preference in cases of knock-knee requiring operative correction. The operation of Macewen[111] is preferable in most cases; in some cases, where the deformity is in the tibia, a linear osteotomy of the tibia and fibula should take its place. Macewen reported two deaths in 1384 operations by English surgeons.

Osteoclasis may be performed by the aid of one of the newer osteoclasts, but is not in great favor, as the fracture must be made too near the joint.

Epiphyseolysis consists in the breaking loose of the lower epiphysis of the femur and its displacement to the inner side. The operation is performed by laying the child on the side, with the inner condyle of the femur resting on the padded edge of a table, the knee-joint and leg projecting, and by bearing down on the leg, the epiphysis is loosened and the deformity corrected.[115]

The objections to the operation advanced are that the growth of the epiphysis may be interfered with.[116] This, it is said, does not occur in cases which have been observed over a period of years, and Codivilla reported 1863 cases without a single disturbance of growth. That rupture of the external lateral ligaments of the knee and fractures of the lower end of the femur do sometimes occur is accepted, but these accidents are said to be rare, except for the tearing off of spicules of bone which occurs in 54 per cent. The operation has not yet found favor in America, but its European advocates claim for it a better correction of the deformity.

Genu Recurvatum.—This name is applied to a hyperextended position of the knee.

It occurs—(1) as a congenital deformity; (2) as the result of anterior poliomyelitis; (3) as the result of hip disease treated by traction where the pull has been largely upon the leg; (4) in tabes; (5) after trauma, and (6) rarely after inflammatory affections of the knee-joint.

The treatment of the affection is carried out by a splint consisting of two uprights jointed at the knee, by which hyperextension of the knee is prevented.

Loose Knees.—An instability of the knee characterized by lateral mobility is an affection seen—(1) sometimes after destructive disease of the joint not followed by ankylosis, as in tabes; (2) as the result of trauma; (3) as a sequel of unsuccessful excision; (4) in rare cases of anterior poliomyelitis; (5) in rickets; and (6) in rapidly growing young children.

The treatment of such cases consists in the use of a fixation splint for the severest cases or a splint permitting only anteroposterior motion.

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CHAPTER XXIX.

SURGERY OF THE LYMPHATIC SYSTEM.

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ANATOMY.

It is of the highest importance that the surgeon should be fully equipped with a knowledge of the anatomy of the lymphatic system, a portion of the human economy of practically universal presence, whose liquid contents are variously estimated as equalling from one-sixth (Bidder) to one-third (Krause[1]) of the weight of the entire body, and whose diseases are constantly and deservedly attracting increased attention. It is pertinent, therefore, to indicate a few points which will be especially serviceable to the surgeon.

The *capillaries* of origin of the *lymphatic vessels* begin by blind extremities. These minute lymphatics, by their union, form larger vessels, which have a network arrangement (reticular) from which the lymph is gathered by collecting vessels (tubular) of still greater size. The entire system of vessels is lined with delicate epithelium, the cells of which are in close contact, and, according to the latest investigators, present no stomata between them. The lymph itself is not to be regarded as a simple product of filtration, but as a secretion, resulting from the cellular activities of the tissues. As His put it, all the cellular elements of the tissues are to be considered as bathed in a sea of lymph. The vessels constantly absorb whatever liquid is presented to them. Solid matter is taken up through the agency of phagocytic leukocytes, which enter and leave the blood- and lymph-vessels by virtue of their amœboid properties.

At irregular intervals the vessels are interrupted by the *lymph nodes* (or *lymphatic glands*), in which they break up into capillaries, and bring their contents into most intimate relations with the substance of the node. Probably the nodes promote the flow of lymph by their rhythmic contractions, which dilate the afferent vessels, while closing the efferent, and *vice versâ;* it is certain that they perform a most important service by detaining foreign particles,—bacteria, pathogenic cells, etc.,—and, as far as possible, destroying them. If the disease material is not too abundant or too virulent, the nodes to which the vessels bring it arrest its progress and transform it from injurious to harmless matter. If, however, these nodes are incompetent to contend successfully with all this material, some of it is carried to the next series of nodes, which do what they can to complete the work. Thus, the nodes are the great system of defense in the economy. Illustrations of this continually present themselves. The germs of tuberculosis, diphtheria, pneumonia, and other diseases are constantly in and around human habitations, and probably the system of almost every adult has repeatedly been invaded by these common affections; but, in the huge majority of cases, either the attacking party has been so small, or its ammunition so feeble, that its onslaughts have been successfully met by the valiant and watchful garrisons of the outposts, and the skirmish has created but a trifling disturbance, and possibly its existence has escaped recognition. Friedländer reported 133 necropsies at the New York Foundling Hospital in which tuberculous lymph nodes were found in the chest in every case, irrespective of the cause of death.

The rapidity with which nodes become infected is well shown in the case of carcinoma. Practically, it may be regarded as certain that, however early a diagnosis is made, the nearest related nodes will be found involved—probably not sufficiently enlarged to be felt through the deep fascia, under whose cover almost all lymph nodes are concealed, but on microscopic examination. The incapacity of the nodes to destroy the cells of cancer is notorious, and the lesson of the facts just stated is obvious—the promptest removal of the neoplasm and of all nodes that possibly can be tainted. The more perfectly this rule is observed, the better will be the prospect of extirpating the disease. Where cancer has an opportunity to gain a strong foothold before its presence is declared, there is no probability of cure. In a record of 481 vaginal hysterectomies for carcinoma, there were 478 deaths, mostly from recurrence in the pelvic nodes.[2]

It is believed that, as certain nodes become functionally crippled by pathologic changes, new nodes are developed at various points in the connective tissue.

The *thoracic duct*, through which the greater part of the lymph reaches the blood, is subject to much more variation than was formerly known—a fact of great importance, as will be seen later when its injuries are considered. The size of its terminal portion depends upon the presence or absence of branches given off to the veins as it rises through the thorax. If no such branching occurs, a wound of the upper end is a vastly graver matter, as in such case the entire quantity of lymph carried by this vessel may be diverted from its normal destination and the patient starved to death. Occasionally the duct is double in the whole or a part of its course. Sometimes, just before ending, it divides into branches, which may open separately into the great veins at the root of the neck.

Whenever a node is found diseased, search should be made for the cause of the infection in the region which is drained into this node.

INJURIES OF LYMPH-VESSELS.

The thoracic duct is so well guarded by the fact of its situation that it is very infrequently wounded. It may be opened in the belly or chest by crushing injuries, especially by such as fracture the bodies of the vertebræ; by stabs and shot; by ulceration extending from adherent and degenerating carcinoma or tubercle; possibly by atrophy, caused by the continuous and increasing pressure of an aneurism. In any such case the effects, though profound, are unlikely to be ascribed to their correct cause until the fluid that has escaped comes to light. It may flow into the peritoneal cavity and produce chylous ascites; or into the pleural sac and give rise to chylothorax; it may dissect a channel behind the peritoneum and make its appearance in the groin, or behind the pleura and reach the root of the neck. In its cervical portion the duct may be injured in the various ways above mentioned, and, additionally, by a cut or tear during an operation for the removal of morbid growths in the left supraclavicular fossa, especially if there are adhesions. Repeatedly the damage has not been observed at the time of its occurrence or until some days have passed. Then the leakage of a milky fluid or the distention of the field of operation calls attention to the trouble, the diagnosis of which cannot be long in doubt. If the lymphorrhea is profuse and is not arrested, the patient is doomed, and probably dies in a fortnight from inanition. The symptoms leading up to the fatal termination are characteristic: rapid emaciation, asthenia, great thirst, vertigo, cyanosis, and syncope. Possibly the establishment of chylothorax may precipitate the end by compression of the lung.

If the surgeon is cognizant of the wound at the time of operation, he should treat it promptly. If the duct is visible and the incision can be closed, it should be sutured as is a large vein with a lateral rent. Pressure-forceps have been used with success instead of stitches. When the duct has been cut completely across, the best practice is to implant it into the internal jugular vein,[3] and a perfect result will probably ensue. Should the surgeon distrust his ability to accomplish this very delicate feat, he may follow the plan of Cushing, which consists in encircling the duct on the further side from the vein with a ligature, which is left untied, and then packing the wound with gauze, in the hope that collateral lymph-vessels will assume the work of the duct. If the leakage proves to be uncontrollable by the tampon, the ligature is tied in the hope of final readjustment of the collateral lymph-flow, or of the assistance of unusual anastomotic branches in connection with veins.

If the terminal portion of the duct has been for a long time subjected to the pressure of a neoplasm, there is more probability of the existence of collateral branches, which serve as outlets, and the seriousness of a wound in the duct is by so much diminished.

A small wound may be closed by a clot spontaneously formed; but no such result can be anticipated in the case of a large opening.

To render the duct more conspicuous and thus more readily avoided, it has been suggested that the patient be given from four to six ounces of cream three hours before any operation in which the duct may be imperiled.[4]

After a wound of the duct the patient should be kept very quiet, and given as little food as is consistent with the continuance of life, and that little should be proteid entirely—the purpose being to prevent the filling of the duct and to promote the apposition of the edges of the opening.

Wounds of the right lymphatic duct should be managed as is advised for the thoracic.

Small lymph-vessels are necessarily severed in every incision, wherever made; but these wounds require no attention.

A *subcutaneous lymphorrhagia* may result from a contusion sufficiently severe to rupture a number of lymph-vessels. The signs of this condition, in addition to swelling, are fluctuation following the blow, and persisting on account of the indisposition of the lymph to coagulate; absence of fever and of pain; and the demonstration with an exploring needle of the presence of clear, yellowish fluid. A pressure bandage gives the proper treatment; if this fails, the tumor may be opened and its contents evacuated, the most scrupulous attention to asepsis being absolutely requisite for the safety of the patient.[5]

Diseases of Lymph-vessels.

INFLAMMATION OF LYMPH-VESSELS.

Lymphangitis is so frequent that the belief obtains that all diffuse diseases of the superficial and the deep tissues are mainly lymphangitic. Its cause is always an infection, generally streptococcic. Most infections

Fig. 473.—Abscesses from Lymphangitis (J. F. Binnie).

are conveyed by the lymph in its minute intercellular channels, from these being taken up by the true vessels. The inflammation follows the introduction of microörganisms into wounds, often of the most insignificant size. But trauma is not essential, since it is possible, though unusual, for the virus to traverse the unbroken skin. Having entered a lymph-vessel, the bacteria produce thrombi, the vessel-walls become infected, and soon the adjacent tissues are saturated with the poison. Lymphangitis of the minute network of vessels is called *reticular;* affecting the larger collecting vessels, *tubular*. The two forms often coexist. The reticular variety is erysipeloid, as observed in some cases of circumscribed dermatitis—the inflammation extending at the periphery, while it disappears at the spot of original infection. A condition of general debility predisposes to the inflammation. The disease may be trivial if the products of the invading bacteria are not of unusual virulence. Among the very serious causes are infection by the discharges from septic wounds and from decomposing animal matter, as that introduced at post-mortem examinations; by the bites of venomous serpents; and by the pathogenic material of some diseases—glanders, for example.

In reticular lymphangitis affecting superficial parts, irregular areas are seen to display the classic evidences of inflammation, the swelling being edematous. In tubular lymphangitis near the surface, red lines, running toward the center from the periphery, indicate the precise location of the principal affected vessels. As the disease progresses its extent is shown by the spreading of hyperemic areas from these tubes, and the related nodes are invaded. Unless the disease is arrested at this stage, extension may occur indefinitely, attended with high fever, general septic infection, chills, vomiting, suppuration, delirium, and even death.

When the deep vessels alone are inflamed, the pain is more violent, and the part affected is very hard. These cases are more difficult of diagnosis and treatment. Deep abscesses must be watched for.

The endocardium, pleura, and other parts may be the seat of metastases. Any lymphangitis may extend from the center to peripheral parts, though the usual course corresponds with the flow of the lymph-stream.

The **prognosis** is not necessarily bad, unless the infection becomes general, as it may through phlebitis or periphlebitis.

Treatment.—The keynote of treatment is antisepsis. Packs of gauze, wrung out in hot solution of corrosive sublimate (1 : 2000) in 50 per cent. alcohol, or of carbolic acid (1:40) in water, covered with oiled silk, are most useful. Abscesses should be opened freely, drained, and treated antiseptically. The general system must be supported, the emunctories kept active, and anodynes used cautiously, if required at all.

OBSTRUCTION OF LYMPH-VESSELS.

Whatever in any way prevents the normal flow of lymph from a part or organ creates such an accumulation in the vessels of the region involved as to distend their walls, and, by internal pressure, to cause an osmosis of the fluid into the surrounding tissues. If the obstruction continues, the distention becomes so great as to overcome the restraining influence of the valves, and the vessel, which previously was moniliform, now becomes stretched into a fairly even cylinder, a condition known at *lymphangiectasis*. When the dilatation occurs in a lymph node, it constitutes *lymphadenectasis*. When many of these dilated vessels are separated from one another by only a small amount of intervening tissue and compose a more or less discrete mass, the tumor is called *lymphangeioma*. The part into which the lymph exudes becomes infiltrated with the fluid to such an extent as to become greatly swollen, and thus displays *lymphedema*. If, by any chance, such as mechanical injury, thinning from overstretching, or ulceration, a perforation is effected in a dilated lymph-vessel, a flow of the contained lymph occurs, called *lymphorrhea*. When such an escape of lymph is very great, it constitutes *lymphorrhagia*. The occlusion of lymph-vessels, which are chyle-bearing, and their leakage into the virtual cavities of the serous membranes, give rise to *chylocele,* when the tunica vaginalis testis is implicated; to *chylous ascites* (chyloperitoneum) when the accumulation occurs in the peritoneum; to *chylous pleurisy* (chylothorax) when the pleura is the part involved; and to *chylopericardium* when the inclosing membrane of the heart is affected. Sometimes emulsified oil appears in the urine, constituting *chyluria,* and is due to chylous lymphorrhea into the bladder or some other portion of the urinary tract; and a similar fluid mingled with the feces betokens a rupture of lymphatics in the small intestine, and the disease is known as *chylorrhea* (*chylous diarrhea*). Lymphatic obstruction is, also, the cause of the monstrous overgrowths of various members constituting *macromelia.* Finally, enormous hypertrophy of whole limbs and other parts may result from occlusion of their lymphatics, the disease being known as *elephantiasis.* An allied and commonly antecedent condition is called *lymph-scrotum.*

Fig. 474.—Elephantiasis of Leg (A. C. Smith).

The mere enumeration and brief definition of these diseases are sufficient to attest the importance of the accident of obstruction of lymph-channels; and, therefore, before entering upon the consideration of these affections in detail, it is desirable to study the various methods by which this condition is induced.

The **causes** of lymphatic obstruction are, in some cases, external to the vessels; in others, internal. The principal external causes are pressure from a neoplasm, cicatricial contraction, the extirpation of the lymph nodes of a given set of vessels, or the ligation of such a group of lymphatics. Of the internal causes, there should be mentioned the presence of cancerous or tuberculous material in the vessel. Obstruction of the thoracic duct may be caused by thrombosis of the left brachiocephalic vein, and by the backward pressure of blood in the subclavian in cases of tricuspid insufficiency. But the chief internal cause is the lodgment of a parasitic worm in a lymph-vessel. The last named is by far the most frequent incident in the production of occlusion; and, because it is brought about by a chain of events of a remarkable character, only recently discovered, a knowledge of which is essential to a correct understanding of the prognosis and treatment, as well as the etiology of the condition, it is important to study this causative factor before proceeding to the consideration of the maladies which are referable to it or to the simpler means of obstruction. The parasite in question is a filaria, and the state which it produces is called *filariasis.*

Filariasis.—In many tropical and subtropical countries a notable proportion of the inhabitants have long been known to harbor in their blood great numbers of a microscopic parasite, called *filaria sanguinis hominis nocturna* (see Fig. 29, Vol. I, p. 140) (the thread-worm appearing at night in the blood of man). Microscopic examination of the peripheral blood of an individual who entertains these unwelcome guests gives very different results according to the time of day at which the specimen is drawn. From about six o'clock in the morning until the same hour in the evening the usual normal appearances are observed; but from the latter time onward for twelve hours the view is very different. Early in this period a few minute worms are observed, and from hour to hour their number increases, until, at about midnight, the blood swarms with them, every field presenting so many wriggling animalcules that attention is distracted from the corpuscles. Then, after a time, their number undergoes retrogression, the examination in each successive hour revealing fewer and fewer, until, soon after six o'clock in the morning, the blood resumes its normal aspect. The appearance of the parasite regularly at night entitles it to its appellation, "nocturna"; but, although the name is well deserved in ordinary circumstances, exceptionally it is inappropriate. Experiment has demonstrated that, if the patient is caused to change his habit of sleeping and to turn night into day in this regard, the worms, also, alter their custom, and appear during the half of the twenty-four hours in which he takes his slumber. This strange phenomenon does not make it clear what influence determines the coming and going of the worms; for, in the usual conditions, they make their advent hours before the accustomed onset of sleep, and begin their retreat hours before the period of slumber commonly terminates.

These creatures have a transverse diameter nearly that of a colored corpuscle of the blood, and a length of about $\frac{1}{140}$ inch (180 microns). Each is inclosed in a delicate, transparent sheath that fits it so very loosely as to permit a considerable degree of movement within it. The worm is in constant motion, writhing in a very lively manner, but not moving actively from place to place. It does not seem to possess differentiated organs.

For a long time the real nature of these animals was unrecognized, though they seemed to have some relation to certain diseases, as lymph-scrotum, chylocele, etc., being found in the blood of persons afflicted with these maladies. But it is now proved that they are the embryos of a species of nematode, called, from its discoverer, *filaria Bancrofti.* The life-history of this parasite is equally interesting from a scientific point of view, and important from a medical. The embryo does not get beyond that primitive stage of its existence as long as it remains in the body of its human host. It is essential to its development that it should enter the body of some one of eleven varieties[6] of mosquito, remain there until a certain degree of progression toward maturity is attained, and then obtain entrance to a human body again (not necessarily the same one, though this occurrence is entirely possible), and there complete the cycle of its wholly parasitic existence. The details of this series of steps are worthy of note. A female mosquito—for the males are harmless—more likely than not a *culex pipiens*, inserts its sting into the skin of a victim of filariasis and sucks her fill of his blood. The nocturnal habits of the predatory insect and of the wriggling visitors in the blood coinciding, the meal of the voracious feeder includes not only plasma and corpuscles, but also filarial embryos. It was formerly supposed that as soon as the culex satisfied her sanguinary appetite she sought a quiet pool and devoted herself to the laying of her eggs; and, having fulfilled her maternal mission, fell into the water and was drowned. Her body decomposing, and the embryo filariæ, which had escaped digestion, being liberated in the water, it was thought that they there found themselves in a medium especially favorable to their development; and, growing to a certain size, they awaited ingestion into the stomach of some human being, whose thirst rendered him indifferent to certain observances that are practised by those who are fastidious about excluding foreign matters from their drinking-water. Thus obtaining entrance to the alimentary tube of the kind of host essential to their vital progress, they bored their way from the stomach or bowels into the tissues. The natural history of the mosquito has been carefully studied in the past few years, and positions formerly considered strong are now known to be untenable. An unmolested mosquito does not die after a single debauch of blood, but lives two or three months, and may feast on its favorite dish many times—indeed, every four or five days. If filarial embryos are immersed in water, they sink, and die by imbibition of that fluid in twenty-four hours. It is not known that they would escape digestion if taken into the human stomach. The truth of the matter is as follows:[7]

As soon as the embryos enter the stomach of the mosquito they lose their delicate sheath (*ecdysis*), and, perforating the intervening parts, lodge themselves in the thoracic muscles of their host. Here they lie quiescent for some weeks, and attain a considerable development, various organs being differentiated in their apparently homogeneous bodies, and their size greatly increasing. Then they resume motor activity, tunnel their way into the insect's head, and steer for her proboscis, in which two or more may be seen at a time. When this weapon, loaded to its muzzle, as it were, with living projectiles, as well as the more familiar virus, is driven into the skin of an unfortunate of the human kind, it may remain as long as two minutes—a period ample for a filaria to puncture the epidermis of one host, and, accompanied by a numerous group of brothers and sisters, to plunge into the subcutaneous areolar tissue of another. From this point the precise steps in the progression of the filariæ is a matter of conjecture, and not, as yet, of proof. But we do know that they seek the large lymphatic vessels, and instinctively travel toward the periphery. They commonly go in companies, a male and a female together, and frequently a number of each sex in a group. Lothrop and Pratt[8] found two males and seven females in a bunch in the lymphatics of the epididymis. Having traveled as far as they are able to go comfortably in the constantly narrowing channel, they lodge; and, being situated in an environment of food peculiarly adapted to their needs, grow and develop into mature filariæ Bancrofti. The fully grown worm is like a delicate, opaque thread, of the thickness of a human hair, and from three to six inches (7 to 15 cm.) long. It is very difficult to detect on account of its tenuity, and is often broken in removal. The body of the female is largely occupied by the uterus and vagina, which are crammed with ova. Generally its offspring are born alive, and, being set free in the lymph-current, are carried by it to the great veins near the heart, and thus enter the blood-vascular system, in which they thereafter remain as embryos (unless discharged through a rupture or puncture), awaiting abstraction by such an insect as injected their partly grown parents into the system of their human host. Apparently they occasion no inconvenience to the person whom they inhabit, being of such size that they can pass readily wherever a colored corpuscle of the blood can go. Indeed, it is said that, in some parts of Africa, as many as 50 per cent. of the inhabitants are infected, and yet conditions of disease referable to filariasis are seldom manifested. But it sometimes happens that the mature female aborts and discharges her eggs before they are hatched; and these, containing each an embryo coiled up and having a diameter three times as great as that of the released viviparous embryo, are apt to obstruct small vessels and produce the diseases that result from occlusion. Cases have been observed in which filarial embryos were found in the urine, in the fluid of hydrocele, or in the discharge of lymphorrhea, while there was an entire absence of them in the blood. This unusual phenomenon is explained by the supposition that the parent worms, before beginning to breed, have excited such an inflammation in the vessel of their choice as to wall themselves off from communication with the portion of the tube nearer the heart. Their offspring would thus be unable to enter the blood-vascular system, but could appear in the lymph toward the periphery.

Filarial obstruction is possible, also, without the appearance of embryos either in the blood or the lymph. Suppose, for example, that an unmated worm—a bachelor male or a virgin female—blocks a lymph-channel. The occlusion may be perfect, and yet no proof of the parasitic origin of the trouble can be found in any fluid of the body.

Several theories of more or less ingenuity have been advanced to account for the absence of the embryos from the peripheral blood in a certain moiety of the whole day, and a number of guesses have been made as to the portion of the body which harbors them during this period. Nothing definite, however, was observed to justify any hypothesis on either of these points until a post-mortem examination was made on the body of a suicide who was known to have filariasis. In this case it was demonstrated that the embryos had retreated from the surface to the larger vessels, particularly the arteries, the greater number being found in the vessels of the lungs; but no physical or physiologic explanation has been given of their alternation between the superficies and the depths of the organism. It is still a mystery why these parasites, which can pass through the capillaries as easily as can the colored blood-corpuscles, and which, on the slide of the microscope, seem to have no locomotive capacity, are not present in all portions of the blood-vascular system at all times; why they should congregate at the surface at night for a mad revel, and retreat to their fastnesses in the internal organs during the daylight hours.

The duration of life of the parent worms is unknown. The regions in which filariasis prevails are those in which mosquitos are a perpetual pest; and it is not necessary to ascribe prolonged existence to the mature nematodes, for repeated and frequent injections of young and active specimens are highly probable, even where there are but few victims. But, in some of the comparatively few cases in which the fully grown worms have been removed alive by operation, the patients have been absent from their native tropics for years, and this would appear to show that the parasites are capable of decided longevity.

The length of life of the embryos that remain in the body is largely a matter of conjecture. Where parent worms have been removed, it has been observed in some, but not all, cases that the blood was free from embryos when examined subsequently; but there is a lack of definiteness concerning the time that elapsed between the operation and the blood-test. Where the embryos are found in the blood after the abstraction of mature worms, we are entitled to think that other parent parasites have escaped removal, and still continue to make contributions of offspring to the blood. There is room for speculation, also, as to the final disposition of the embryos. They do not live indefinitely; but we are puzzled to understand in what organ and by what process they are ultimately eliminated.

During the early stages of filariasis a leukocytosis and an eosinophilia are present;[9] they are cyclic, following by a few hours the periodicity of the embryos in the peripheral circulation. As the disease progresses the leukocytosis and eosinophilia gradually diminish until the normal state is reached. It has been thought that the eosinophiles serve to protect the body from the toxins of the parasites.

Manson, who has won deserved fame for his discoveries in connection with filariasis, says, "in many cases we know that hundreds of parent filariæ are present" in the body, their great number being due to repeated infections. They have been found in the scrotum, the fluid of hydrocele, the epididymis, the spermatic cord, the ovary, the inguinal and other lymph nodes, the arm, and the leg; and one who studies the subject would feel no surprise at the announcement of their discovery in any other part, inasmuch as various maladies can best be accounted for on the theory of the lodgment of filariæ in situations inaccessible to the surgeon.

The diseases directly traceable to filariasis are thus enumerated by Manson[10]: Abscess, lymphangitis, varicosity of the inguinal and of the axillary lymph nodes, lymph-scrotum, cutaneous and deep lymph-varix, orchitis, chyluria, chylous dropsy of the tunica vaginalis, chylous ascites, chylous diarrhea, elephantiasis of the leg, scrotum, vulva, arm, and mamma; and besides these, others are certainly encountered.

The parent worms do harm to their host by obstructing lymph-vessels. This result may be achieved in different ways. A worm may plug a vessel of a size too small to permit its passage; its presence as a foreign body excites irritation; its body develops toxins; inflammation is inaugurated; plastic material is poured out, and a degree of damage ensues that insures the continuance of trouble, even if the parasite becomes dislodged. It is highly probable that at least two helminths, a male and a female, are closely associated in the great majority of cases. They have a tendency to snarl themselves into a bunch, and thus may easily obstruct a lymph-vessel of considerable size. Sometimes a nematode dies and gives rise to a thrombus, which partially blocks a vessel, whose lumen is many times larger than the parasite. A mass of connective tissue is ultimately formed around the dead body and fills the entire passage, which is thus permanently closed.

The presence of these creatures gives rise to febrile action, which is called filarial fever, of which the symptoms are pain in the head, back, and limbs, chills, nausea, lassitude and drowsiness, stretching and yawning, and high fever (104° F. and more), with marked debility. This lasts a day or two, and then passes off, quite frequently in a profuse perspiration. Such attacks recur at very irregular intervals. If the patient remains in the tropical country in which he acquired the disease, the time between the seizures is likely to be short as compared with that experienced if he removes into a cool region.

The tropic and semitropic lands are the home and chief fields of manifestation of filariasis, and in some countries a large proportion of the inhabitants are afflicted with it. The extremest case authentically reported is that of the Society Islands, in which it is estimated that 70 per cent. of the people entertain these parasites. But sporadic cases are constantly being discovered in the temperate zones, and their number is noticeably increasing. Indeed, since the method of propagation is clearly demonstrated, it is plain that filariasis may easily become a common disease in America, especially in view of the intimate relations of late years established between our insular dependencies and the United States. Every person in whose blood are the embryos is a menace to the entire community.[11] Of course, the method of prevention of the spread is manifest. As in the cases of yellow fever and malaria, the extermination of the mosquito is the essential step. No mosquitos, no filariasis.

Treatment.—The treatment of existing filariasis is strictly surgical—no medicines have the slightest effect upon the parent worms or their progeny. Sometimes the operation, which is undertaken for the removal of some disease caused by filariasis, is successful in ablating also the mature helminths, on whose presence the disease depended; and then an entire cure may be effected.[12] But, in a great many cases, the parasite is situated in a part inaccessible to operative procedure, and, the cause remaining, the best effect of the operation is merely palliative. The particular operation needed will be specified in considering the several diseases dependent upon filariasis.

It is necessary, before closing the subject of filariasis, to state that the variety herein studied is only one of six that are described. These are distinguished most readily by their embryos. That here described is the "nocturna." Another, very similar in appearance, is called "diurna," from its detection in the peripheral blood only by day, and is not known to be related to any disease. A third, somewhat smaller than the two preceding, is always to be discovered in the blood of the surface by night and by day,

Fig. 475.—Elephantiasis of Scrotum (Non-parasitic).
(Charity Hospital Collection, New Orleans, La., service of Dr. S. P. Delaup.)

and hence is named "filaria perstans." Others, whose pathologic position is not positively determined, need not be mentioned, as they do not seem to be related to lymphatic diseases.

Elephantiasis.—The name of this malady was suggested by the characteristic appearance of an advanced stage of the disease in the part most frequently affected. Briefly, it consists in a monstrous hypertrophy of the skin and subcutaneous areolar tissue. It is sometimes called elephantiasis Arabum, to distinguish it from elephantiasis Græcorum, a synonym for leprosy. It is very common in tropical and subtropical countries, and is occasionally seen in temperate regions. Indeed, it has long been a recognized endemic, though affecting but a small percentage of the people, in the southern portions of the United States. In the Krim country of Mendiland eight out of ten men have the disease in some form; and it is so frequent along the whole western coast of Africa that men of that region who do *not* have elephantiac enlargement of the scrotum are regarded as abnormities[13]—a grotesque example of satisfaction with misfortune, though not so absurd as the pride taken by Chinese ladies in their artificially deformed feet, or by Caucasian women in their monstrously and injuriously constricted waists.

As will be appreciated when its etiology is studied, a sporadic case, when due to the usual cause, endangers the health of everybody in the immediate neighborhood; while the probability of its rendering its victim a cripple, the difficulty or even impossibility of effecting a cure, the danger attending the only available methods of radical treatment, and the disgusting features of the disease—all these things make it important not only for the medical profession, but also the community, to understand the method by which it is generally propagated.

Fig. 476.—Elephantiasis of the Scrotum (Ziemann).

Fig. 477.—Elephantiasis of Scrotum Caused by Pressure of a Double Truss (W. F. Campbell).

Obstruction of lymph-channels, however occasioned, is responsible for the tissue-changes which constitute elephantiasis. The case shown in Fig. 477 is a typical illustration of elephantiasis of the scrotum, and was caused by the wearing of a double truss constantly for a series of years.[14] As long as the patient wore a truss for hernia of only one side, there was no enlargement of the scrotum; but when a rupture developed on the opposite side, and he was obliged to wear a double truss, the anastomosis between the lymphatics of the two sides, which had been sufficient to prevent obstruction when a single truss was worn, being rendered inoperative when firm and persistent pressure was applied to all the lymphatic trunks that drained the region, the outflow of lymph was completely stopped, and the hypertrophy ensued. The huge majority of cases, however, are due to filariasis, and the reader is referred to the section of this chapter immediately preceding for an account of this parasitic disease.

The immediate effect of the detention of lymph in a part is the production of swelling, which is most pronounced in the superficial portions. The tissues are constantly bathed in lymph, which, being rich in the elements of nutrition, furnishes every cell and fiber with an amount of pabulum altogether out of proportion to its needs. But the tissues do not equally profit by this extraordinary opportunity. The white fibrous, the principal material in connective tissue, and that most easily produced, is the most eager and capable appropriator of food; and, consequently, it grows at a greater rate than any other. So rapidly, indeed, does it increase that organs into whose composition it enters soon have an abnormal amount of it. For example, it is the chief ingredient in the sheaths of the fasciculi of muscle; and these envelops thicken to such an extent as to interfere with the nutrition of the contractile fibers, and cause their degeneration, with consequent and progressive loss of power. The periosteum may be so overfed as to produce shapeless exostoses; and the squeezing of the nerves by the ever-growing connective tissue produces severe pain. The skin and subcutaneous areolar tissue become in time enormously thickened, this result being hastened in most cases by repeated attacks of inflammation of an erysipelatous character. Each new outbreak of inflammation is attended with systemic disturbance, the classic symptoms of fever being displayed for a time varying from twenty-four hours to five days. The periods between these exacerbations vary from a few weeks to several months, and the successive attacks gradually diminish in severity. In a well-advanced stage, which may not be reached until ten years have elapsed, the skin is warty, overgrown to such an extent that it is thrown into thick folds, which may overlap one another, and the cuticle is piled up in horny plates, suggestive of the designation "coat of mail." The deep creases collect and conceal the exfoliated epithelium, the secretions of the skin, and quantities of extraneous matter; and the decomposition of these gives rise to eruptions, inflammation, and ulceration, with the attendant discomforts of itching, soreness, and stench.

If the process continues, the muscles and other parts atrophy, partly from the constant pressure, partly from disuse, for the limb becomes so prodigious and so heavy that its size and weight interfere most seriously, if they do not absolutely forbid, enough exercise to preserve a normal tone of the muscles. Even the bones degenerate, in advanced stages sometimes becoming so soft that their incision requires not as much expenditure of force as is necessary in cutting dense muscle.[15] In many acute cases there is synovitis of the joints in the affected limb.

The order of frequency with which different parts are involved is as follows: the lower limbs, the external genitals, the upper limbs, and the mammæ—the last two localities being attacked very rarely. The almost invariable selection of the lower extremities and the external genitals for the manifestation of filarial elephantiasis seems to point to the entrance of the partially developed nematodes into the thoracic duct, and then to their forcing their way against the current by the same instinct that inspires certain fishes at the breeding season to swim up stream, and the spermatozoa to wriggle their course through the oviducts against the flow created by the cilia of the epithelium. That the worms sometimes get into the lymphatics of the upper extremities and the breasts may be due either to accident or to an anomaly of instinct.

Fig. 478.—Elephantiasis of the Vulva (J. C. White).

Some authors lay great stress upon the necessity of repeated attacks of inflammation in the production of elephantiasis; but cases are recorded in which no evidences of inflammation were observed. The mere occlusion of the lymph-channels of the affected part is sufficient to effect the result.

When the scrotum is the part attacked, the weight of the tumor drags so strenuously upon the spermatic cords as to induce inguinal hernia in many cases; indeed, this complication is to be anticipated, and, in operations, must be especially borne in mind. The penis, which is rather exceptionally involved in the disease, is gradually concealed by the outgrowth of scrotum all around it, and lies in the depths of a well, which is kept foul by retained urine, smegma, and other secretions. The testes are pulled down to the lower part of the growth. Chylocele is frequently associated with this condition. A case of elephantiasis scroti is reported in which the mass weighed 224 pounds. Many cases have been observed in which it was necessary for the patient to place his scrotum in a wheelbarrow and trundle it before him as a condition of locomotion.[16]

The labia majora are often affected. One labium, which was removed by operation, weighed six pounds and ten ounces.

When elephantiasis invades the penis, the hypertrophy may be as monstrous as that displayed in any other part. In one case the organ attained a length of twenty-seven inches measured around the curves.

It is necessary, before leaving this subject, to state that there are congenital forms of elephantiasis,[17] very rarely seen; except as regards causation, not essentially different from the acquired varieties, and, hence, demanding no more than this passing mention.[18] Occasionally, also, cases are encountered in which, for one or another reason, somewhat limited areas of skin become thick, hard, and brawny, and, therefore, have some superficial resemblance to elephantiasis and are called by this name.

Fig. 479.—Elephantiasis of the Penis. The left leg also was elephantiac.

Treatment of Elephantiasis.—The administration of medicines of various kinds has been tried in this disease, but with no curative effect. Iodin and its salts, arsenic, purges, and diaphoretics have been thought to check its progress, but their most enthusiastic advocates do not claim to have observed cures. The temporary improvement supposed to have been seen is probably explicable only as are multitudes of alleged results in every department of medicine, when, in the natural course of the malady, progress is for a time suspended, or, what is more common, hope and anticipation blind the prejudiced observer to unpleasant truths.

Surgical measures only are worthy of consideration. Comfort is afforded, and delay of development effected, by the horizontal position of the body, with elevation of the affected part, elastic bandaging, evaporating lotions, massage, strict cleanliness, and the prevention of all irritation. But, whenever the patient is crippled by the growth, either from its size and weight or from the suffering which it causes, something more radical should be undertaken. When the disease affects a *lower limb*, ligation of the femoral artery has been performed, with the idea of preventing the increase of the hypertrophy by removing its blood-supply; but the uselessness of this procedure has been fully demonstrated. Furthermore, it has so frequently caused gangrene, as might have been expected, that it is now discarded by judicious surgeons. Compression of the large arteries supplying the member involved has been exploited, but with no results that encourage further attempts. In the acute stage punctures of the skin have been made, but must be attended with risk of infection and lymphorrhea, without compensatory benefit. Amputation of the limb has been done in some cases where the size and weight were disabling. When it is performed, care should be taken to make the flaps in healthy tissues. In very recent years, however, so much relief has been obtained by a far less radical and sacrificial proceeding that it deserves more extensive trial. This is the excision of large masses (perhaps as much as six pounds in weight) of the overgrown tissues, and the consequent reduction of the size of the limb to such an extent as to enable the patient to use it with an enjoyable degree of freedom. Rogers[19] has reported a most instructive case, which he treated in this way, without knowing of any precedent operations of a like kind. His patient was twenty-six years old, five feet tall, and weighed 248 pounds. Above the breasts her chest girth was 32 inches; her thighs had a circumference of 38 and 39 inches respectively. Large wedges of skin and subcutaneous tissue were cut out, greatly reducing the size of the limbs (Figs. 480, 481) and vastly improving the health as well as the locomotive capacity of the patient. As the cause of the difficulty is not removed by the operation, there is a constant tendency to recurrence and necessity for further ablation; but almost any sufferer would prefer a method of treatment that would give two fairly good lower limbs, even though needing an occasional trimming, to a procedure that would deprive him of both forever.

Experience has shown that it is desirable to observe certain rules in connection with this treatment. For the preceding week the patient should lie in bed with the lower limbs elevated. Every day a hot tub-bath should be given, the affected parts being thoroughly scrubbed with a stiff brush and plenty of soap—this being necessary to remove the dirt and desquamated epithelium that accumulate in the cracks and depressions of the corrugated and folded skin. A careful washing with a solution of corrosive sublimate should follow. Without these precautions serious infection is likely to occur. More enduring results are produced when the long diameter of the excised masses runs across that of the limb than when it corresponds with it, because by the transverse incision the dilated blood- and lymph-channels are interrupted, and thus the hypernutrition of the parts is diminished. The excised pieces should be wedge-shaped, and the incisions so directed as to result in coaptation of opposite surfaces in the closure of the wound. Large, strong sutures should be passed beneath the depths of the wound to prevent the formation of dead spaces. Where the sides of the wound are of very extensive area, it may be desirable to catch them together along opposite lines by layers of continuous sutures, as in closing muscle-flaps in amputations. Drainage is not requisite if the opposed surfaces are held in contact. Voluminous dressings of gauze, imperviously covered in, and closely confined with

Fig. 480.—Elephantiasis of Legs before Operation (P. F. Rogers).

bandages, are needed to receive the inevitable oozing of lymph, and should be renewed whenever they become soaked. The unburied sutures may be removed by the sixth day. Healing is generally prompt and uneventful.

Fig. 481.—Elephantiasis of Legs after Operation (P. F. Rogers).

These operations may be attended with much bleeding, as the blood-vessels in an elephantiac part are always enlarged. As soon as they are cut, the blood-vessels should be clamped with hemostatic forceps. Of course, there is a profuse outpour of lymph from every cut surface.

If operative relief is not afforded before extreme muscular degeneration has occurred, considerable restoration of the function of the limb is not to be expected.

When the *scrotum* is the part affected, operation affords the only relief, and is not forbidden by the size of the growth, one weighing more than a hundred pounds having been successfully removed. The chief danger is from hemorrhage, the supplying vessels being enormously enlarged; but this can be reduced to a minimum by the use of stout rubber tubing, constricting the neck of the tumor, and then carried around the waist and fastened. As preliminaries the surface should be cleansed and sterilized, as above prescribed for the lower limb, and the blood and lymph drained out of the scrotum as thoroughly as possible by its elevation for some hours. An incision from the external abdominal ring downward on each side exposes the spermatic cords, which are then bluntly dissected out, and each testicle freed from its gubernaculum. The testicles and cord, wrapped in a sterile cloth, being held out of the way, the penis is released from its incarceration by slitting up the canal at the bottom of which it is embedded, dividing the foreskin at the corona, and separating the organ from its surroundings. The first incisions are then united by a connecting cut, and the scrotum ablated. All diseased tissue must be removed. The penis and testicles are now to be covered with flaps of skin from the perineum and the inner side of the thighs; but, if there is insufficient material for this, the defect will have to be supplied by granulation. The excellent result obtained in the case depicted in Fig. 477 is shown in Fig. 482. The death-rate is about 5 per cent., and the results in the survivors satisfactory. Sexual power may be regained. The surgeon should obtain the patient's permission to castrate in case the testicles are found to demand removal on account of disease.

FIG. 482.—RESULT OF OPERATION FOR REMOVAL OF ELEPHANTIAC SCROTUM (W. F. Campbell).

The operative treatment of elephantiasis of the *labia majora*—removal—needs no special description. When the *mamma* is involved, complete ablation is called for, and the removal of all the axillary nodes that are implicated.

Lymph-scrotum.—After so full a study of elephantiasis, a brief consideration of lymph-scrotum will suffice, because of the resemblances between the two conditions in causation, in symptoms of initiation, and in general appearance, and because the one usually eventuates in the other.

The essence of the disease is dilatation of the lymphatics of the scrotum, depending upon obstruction, and complicated with inflammation. There are repeated attacks of general fever and local inflammation, and the skin becomes leathery and corrugated. The lymph-vessels become so stretched and tortuous that the hypertrophied skin is channeled with sinuses, some of which come to the surface as blebs, thin out from the internal pressure, and burst through the epidermis, causing lymphorrhagia, which may be alarming in its results. The discharged fluid usually contains filarial embryos, and, often, emulsified oil. After a long series of years the lymphorrhea may cease and the scrotum become distinctly elephantiac.

FIG. 483.—LYMPH-SCROTUM (A. T. Cabot).

The only proper treatment is ablation.

Lymphedema.—The commonest and most immediate effect of obstruction of lymph-channels is the exudation of fluid through the walls of the vessels into the surrounding tissues, producing a condition called *lymphedema*. To some extent it is likely to follow any operation that has included the removal of lymph nodes, *e. g.*, amputation of the breast and clearing out the axilla, and, also, the enlargement of nodes by pathologic deposits. The affected parts become swollen, brawny, and rigid, and, if incised, discharge lymph freely. Exceptionally spontaneous relief is afforded by the dilatation of collateral channels.

Persistent elastic bandaging may do some good. If the member involved becomes an intolerable burden, its amputation may be warranted. The flaps in such cases heal well despite the profuse exudation of lymph during the process.

Chyluria.—The characteristic feature of this disease is the appearance of emulsified oil in the urine. Almost always, also, filariæ are found in the urine and the blood. Besides these phenomena there may be no symptoms; but it is not uncommon for the patient to experience discomfort in the loins, bladder, and urethra, and the volume of fluid voided from the bladder is vastly increased.

The urine has a milky appearance, and clots on standing; but the coagulum disintegrates rapidly and cream rises, forming a distinct layer.

If the solidification occurs in the bladder, retention results, with the attendant sufferings, and is not relieved until the clot is broken up spontaneously or by artificial means.

Chyluria depends upon the rupture of dilated chyle-bearing vessels in some portion of the urinary tract. It is possible that non-chyle-bearing vessels may leak into the ureter or bladder, without exciting suspicion of the real nature of the disease, as the only noticeable departure from the normal would then be augmentation of the volume of fluid discharged from the bladder. Chyluria may last indefinitely, or occur intermittently at irregular intervals.

Although the long continuance of the disease may not seriously impair the health, there is great danger of grave consequences on account of the loss of so great a quantity of food, digested at the cost of much vital force.

Treatment should be directed to diminution of the amount of fluid and of fatty material ingested, to quietude of the patient, and to the support of the strength with tonics to atone for the debility occasioned by the constant losses. Clots in the bladder are to be broken up aseptically and washed out. Medicines cannot be relied upon to expedite healing of the ruptures in the vessels.

Chylous Accumulations in Serous Cavities.—Occasionally there is presented to the surgeon a scrotal swelling which has all the signs and symptoms of hydrocele, excepting the translucency that is commonly observed. This lack should excite suspicion that the contents are not merely serous. Withdrawal of the fluid shows it to be milky in appearance; and, if it is permitted to stand, a layer of cream comes to the top. Evidently there has been a leakage from a lymph-vessel of the chyle-bearing group, owing to some obstruction, and this obstacle, more likely than not, is of filarial origin. The condition is called *chylocele.* The diagnosis is rarely made before the fluid is drawn. The treatment is such as is proper for hydrocele.

An identical condition is found, though very rarely, in the peritoneum and in the pleura, constituting respectively *chylous ascites* (*chyloperitoneum*) and *chylous pleurisy* (*chylothorax*). The infrequency of these diseases and the difficulty of inspecting the extensive areas of the serous membranes concerned have prevented their careful study, and their pathology is largely conjectural; but once in a while the presence of chyle in the pleura or peritoneum may be accounted for by the existence of a wound of the thoracic duct, which pours its contents into the serous cavity with which the lesion has connected it. Fracture of the tenth thoracic vertebra has been responsible for this condition. Spontaneous absorption and cure may occur. No positive diagnosis is possible until some of the fluid is drawn out and its character recognized. Even then one should not be content to make a diagnosis merely from gross appearances. Cases are reported in which chyle seemed to be present in the peritoneal cavity; but minute examination showed that fat was absent from the fluid. The turbidity was probably due to lecithin in suspension.

Sometimes it is necessary to discriminate between chylous ascites and other conditions resembling it, in which the milky appearance is due to lymph. Widal and Merklen[20] removed nine liters of milky fluid from the abdomen and found in it large numbers of leukocytes (100,000 per c.c.), and the only elements were lymphocytes and large mononuclear cells. Consequently this was a case of ascites of lymphatic origin. There was, also, some fat (1.45 gm. per liter); but they declare that the mere presence of oil does not prove that the substance is chyle, as large amounts may be present in other circumstances.

When there are symptoms of disease in the neighborhood of the stomach, with very striking emaciation, and especially with a tendency to copious, pale, and fluid stools, obliteration of the thoracic duct should be considered.

Lymphangiectasis and Lymphangeioma.—Lymphangiectasis sustains the relation to the lymph-vascular system that varicosity of veins does to the blood-vascular. The vessels of a part, which are usually of insignificant size, become dilated from inability to empty themselves normally. In resisting the distending force the vessel-walls at first become somewhat hypertrophied. The valves for a time hold tightly, but soon give way, and the vessel, subjected to constantly increasing force, enlarges in every direction—the longitudinal limitations of the part containing it causing it to assume an undulating form. A frequent site of the disease is the spermatic cord, and here the look and feel of the mass of lymph-vessels are entirely comparable to those of a varicocele, with the single exception of the color, which, in this case, is whitish. This is a typical *lymph-varix*.

When such a formation is entirely superficial, it may safely be removed. Many cases, however, are deeply situated in the abdomen, and are inaccessible to operation. They present a grave problem to the surgeon, when, in advanced stages, they extend into the inguinal canal, where they are very liable to be mistaken for herniæ. The opening of a lymph-varix that cannot be ablated is likely to be followed by an uncontrollable lymphorrhagia, and this is one of the calamities of surgery.

An ingenious operation for the relief of lymphangiectasis has been practised by Godlee. In a case of obstruction of the thoracic duct, with consequent dilatation of the inguinal lymphatics, he effected an anastomosis between one of these vessels and the saphenous vein, with the result that the lymphangiectasis disappeared. This procedure is particularly valuable on account of its diverting the chyle into the venous system, and thus saving the patient from the devastating effects of the lymphorrhagia that was constantly impending.

Treatment of an inaccessible varix is only palliative. Rest, lowering of the lymphatic tension by salines, diminution of ingested liquids to the point of the patient's endurance—these are the means upon which one must rely.

When the dilated lymph-vessels are so numerous in a given locality as to constitute a distinct tumor, it is called *lymphangeioma*. It is generally congenital. It may consist merely of lymph-vessels, separated from one another by a variable amount of connective tissue. As the distending force increases, on account of the causative obstruction, absorption of the tissue between the vessels occurs from pressure, and afterward the vessel-walls disappear for the same reason. Thus, the tumor, which originally was composed of a collection of tubes, now has become a cyst, sometimes called a *cavernous lymphangeioma*. The walls of adjacent blood-vessels may be absorbed by reason of the persistent pressure, and a communication between the lumens of the lymph-vessel and blood-vessel being established, the two fluids mingle, and there is formed a *hemato-lymphangeioma*.

In all lymphangeiomata there is liable to be sudden increase or diminution in size, for obvious reasons. When situated in the face and neck, they are peculiarly liable to infection from the neighboring mucous membranes. Circumscribed cystic lymphangeiomata are very readily mistaken for other cystic growths, as cysts of the parotid, mucous cysts of the mucosa of the lips, branchial cysts, and echinococcus cysts.[21]

Lymphangeioma has its favorite sites in the neck, nates, groin, axilla, forehead, back of the thigh, and walls of the mouth. It is sometimes of filarial origin.

The chief danger in this disease is debility or even exhaustion from lymphorrhagia, which is liable to be started at any time by spontaneous thinning of the covering skin or by accidental puncture.

Although removal by operation has been condemned by some surgeons of note, it is the only proper treatment. If possible, the entire tumor should be excised. Fistula with lymphorrhea rarely follows. In filarial cases the worms are frequently ablated with the tumor, and thus the distressing symptoms of periodic fever and pain may be relieved. Wölfler advises incising the cystic lymph-spaces, packing with gauze, and allowing them to heal from the bottom. To this there are grave objections: lymphorrhea, which may be serious, especially in children, and infection. However, when the tumor is of ill-defined outline and cannot be entirely removed with safety, this procedure may be the best practicable, and should be considered.

Macromelia.—The monstrous growth of a part is called *macromelia*. It is a congenital condition, and is thought to be due to obstruction of lymph-channels—in some cases it is obviously so. It is essentially dependent upon a vice of development. Affecting the tongue, it is called *macroglossia;* the lip, *macrocheilia;* the fingers, *macrodactylia;* the foot, *macropodia*.

Macroglossia is a true cavernous lymphangeioma. As the growth progresses a part of the tongue protrudes and remains permanently outside of the mouth. The great size of the organ interferes with speech, deglutition, and respiration, causes eversion of the lips, and distorts the alveolar processes. The projecting portion is marked off from the intra-oral by a groove, caused by the pressure of the jaws, and becomes discolored, cracked, abraded, sore, and painful.

The condition is sufficiently serious to justify a perilous operation. Destruction with the thermocautery is advised in the less pronounced cases, local anesthesia and a clamp to prevent bleeding being desirable preliminaries. In advanced cases ligation of both lingual arteries has been followed by shrinkage of the growth. The best operation consists in the removal of a wedge of tissue, with its base upward, from each side of the middle line of the tongue, and the closure of the gaps with deep sutures. If necessary, several such operations may be done.

Macrocheilia.—This, also, is a lymphangeioma. The diagnosis is almost always easy, the skin being of unaltered color, as is not the case in hemangeioma. The treatment often demands a high degree of judgment and skill. It can rarely be expedient to remove the whole growth when the entire lip is involved; but incision and packing (Wölfler), which may result in improvement, may, on the other hand, cause extensive, perhaps fatal, infection or exhausting lymphorrhea. The excision of wedges from the mass may be cosmetic, but leaves behind diseased tissue, and is peril-

FIG. 484.—CONGENITAL MACROCHEILIA (Matas).

FIG. 485.—CONGENITAL MACRODACTYLIA (Matas).

ous. Although not unattended with danger, the favored procedure of some of the best authorities is the injection of irritating fluids, such as tincture of iodin or solution of chlorid of zinc. Great care should be taken to prevent the extension of these substances beyond the limits of the disease, and, also, to avoid rough handling subsequently to the injection, lest thrombi be thrown into the circulation. Instant death has been known to follow the unguarded employment of such means.

The mammoth growth of the digits (Fig. 485) and some other parts is diagnosticated without difficulty, and its treatment by amputation requires no special elaboration.

DISEASES OF THE LYMPH NODES.

INFLAMMATION.

Lymphadenitis is caused either by extension of a lymphangitis from continuity of tissue, or by infection from material brought from a diseased area through a vessel, which, though a carrier of virus, has itself escaped unharmed. The former of these cases is illustrated by the usual course of events when a peripheral part is poisoned by a dissecting-wound; the latter, by the infection of a node with tuberculosis, introduced from a mucous surface. The poison may be one of several kinds—septic, syphilitic, glanderous, tuberculous, etc. Two forms of the disease are recognized—the acute and the chronic.

Acute Lymphadenitis.—The usual evidences of inflammation are present, but, in mild cases, there may be no fever, and locally only a moderate tumefaction. From this state there may be resolution, with subsidence of all symptoms; or, the condition continuing, it eventuates in chronic inflammation or fibrous induration. If, however, the infection is profound, there will be chills, fever, and various indications of septic poisoning, and the affected node may rapidly pass through the inflammatory process, and break down in suppuration or gangrene. In both of the latter events there is usually *peri-adenitis,* and the destroyed or pus-swollen

Fig. 486.—Acute Cervical Lymphadenitis (Matas).

Fig. 487.—Acute Lymphadenitis with Peri-adenitis (Matas).

node may be completely surrounded by an abscess. The pus tends to come to the surface and discharge spontaneously, but this process is slow and apt to be attended with much destruction of surrounding tissue, and, from imperfection of drainage, is liable to be followed by an ulcer or a more or less deep sinus. Generally more than one node is involved, the disease extending from the one first infected to its neighbors; and, if the inflammation is not arrested, most serious systemic trouble may ensue.

In **treatment** the removal of the cause should first be effected. If the starting-point is an infected wound, it should be drained and made aseptic. Rest of the affected part, cold applications, steady compression, if practicable, are approved remedies. If these do not speedily show good effects, the injection of a few drops of a 3 per cent. solution of carbolic acid is esteemed a preventive of suppuration. This should be repeated daily several times; but, if it does not succeed and pus forms, the abscess should be opened freely, any dead tissue curetted out, pure carbolic acid applied to the raw surface, and the cavity packed with iodoform gauze, which may be allowed to stay two or three days. All sinuses should be laid open, and treated as advised for the incised node. When the healing is slow, it may be quickened by a suture holding the surfaces in contact; or, if this is forbidden, Peruvian balsam may well be applied. Dissecting out the entire abscess has been advocated, but has received very limited approval. During all this local treatment the general condition must not be forgotten. Supportive measures should be adopted, and the system placed in the best possible condition to resist the action of the poisons that have been introduced.

Chronic Lymphadenitis.—This form of inflammation may develop from the acute, and then the node presents a hyperplastic condition and may remain permanently enlarged; but the disease is more commonly the result of tuberculosis (*cf.* Vol. I, p. 658). Until recently this condition was called scrofulous—a term which happily has been discarded as pathologic knowledge has increased. It does not display the classic evidences of inflammation, but comes on insidiously and painlessly; and the tumor may attain a considerable size before attracting the attention of the patient. The nodes involved may be discrete for a time, but later usually coalesce into a hard mass, the inflammation extending to the capsule and surrounding parts and causing extensive agglutination. There is a strong tendency to caseation. Suppuration may ensue early or be delayed many years, and, when it occurs, is probably due not to the tuberculous, but to an added, infection. The pus of the nodes near the surface will generally point at the skin; but that from the deeper nodes is likely to burrow between them, follow the sheaths of muscles and vessels, and reach the surface at distant points.

The nodes most frequently affected are those of the neck, 90 per cent. of all cases being in this locality. This prevalence is due to the fact that the cervical nodes are peculiarly exposed to infection from carious teeth, diseased tonsils, etc. It is not universally agreed that the tuberculous infection comes directly from these oral and pharyngeal foci; for example, Cheyne[22] holds that the nodes become infected by absorption of virus from the parts which drain into them, and then, their vital resistance being lowered, the tubercle bacilli in the blood find them fit places for lodgment and become active. The majority of these cases of tuberculous lymphadenitis occur in the poorer classes, whose hygienic conditions are faulty and whose predisposition favors tuberculosis. More than three-fourths of the cases are found in the second and third decads of life. While, with many patients, the disease remains strictly local, it subsequently becomes constitutional in so large a proportion that it is unsafe to count on its limitation to its original site. Certain cases of tuberculous lymphadenitis are clinically indistinguishable from Hodgkin's disease.

Primary *tuberculosis of the mesenteric nodes*[23] occurs more frequently in children less than ten years old, and is apt to be marked by abdominal pain, anorexia, night-sweats, debility, and emaciation. The enlarged nodes may be palpable, and are more likely to be felt after the bowels have been thoroughly evacuated. Diarrhea may alternate with constipation. A caseated node may break down and discharge into the abdominal cavity, producing general peritonitis or miliary tuberculosis; but tuberculosis of the mesenteric nodes is considered less perilous because of their greater aptitude for calcification. Such calcified nodes may be mistaken for renal or ureteral calculi in an *x*-ray picture.

Chronic lymphadenitis is a serious disease. If the inflammation is merely hyperplastic, the condition is an urgent invitation to tuberculosis; and the huge majority of cases are tuberculous when first seen. There may, indeed, be a spontaneous recovery; but this is to be regarded as barely possible. There is very great danger that the system will become tainted from this focus of dissemination.

Treatment.—Improvement of the constitutional condition is vitally important. Every possible hygienic influence should be invoked, and particular attention given to appropriate aliment. Among medicinal remedies arsenic, iodin, and mercury—one or another being selected, according to the specific needs of the case—have the highest repute, and are generally best associated with tonics. Removal of the cause should, if possible, be accomplished.

Locally, injections are sometimes of value. A solution consisting of iodin 1 part, iodid of potassium 4 parts, water 100 parts may be used—three minims at first, and the dose gradually increased day by day, every part of the node successively being treated. A 5 per cent. solution of chlorid of zinc or equal parts of carbolic acid and glycerin may be employed in a similar way. Thus, suppuration may be prevented and induration promoted, if treatment is prompt; but it may be necessary to continue the injections for months. Painting with tincture of iodin is to be deprecated.

If there are ulcers or sinuses and complete removal is too dangerous, incision and curetting are properly employed, and the cavities should be stuffed with iodoform gauze.

But the best treatment is complete removal, which promptly eliminates the offending nodes, ends the peril of general infection from them, and leaves a scar which is not unsightly and puckered, as is that which follows nature's efforts at ablation. One should not be deterred from entire removal of a collection of nodes by fear of interference with the flow of lymph—a difficulty rarely encountered.

Details of the various operations will be found under the regional headings.

HODGKIN'S DISEASE.

It is not literally true that every author who has discoursed on this disease, which was first described by Hodgkin fourscore years ago, has rebaptized it with a designation intended to convey his notion of its intimate nature; but it is a fact that so many have done so that the subject is painfully overburdened with names, and that its excessive

Fig. 488.—Hodgkin's Disease (Matas).

nomenclature is a distinct hindrance to the progress of knowledge. The confusion is the worse confounded by the employment of some of these titles to indicate other affections. To show that these statements are not exaggerations, the following is a list, probably incomplete, of these designations, with the maker's name appended, when it is known.

Adénie (Trousseau), adenia, adenosis, adenoid disease (Southey), adenolymphoma, anæmia lymphatica (Wilks), splenic anemia, hyperplasia of lymphatic glands, progressive glandular hypertrophy, progressive multiple hypertrophy of lymphatic glands, lymphadenoma, generalized lymphadenoma, lymphadenosis, lymphomatosis, lymphadénie

(Ranvier), lymphadenia, lymphoma, malignant lymphoma (Billroth), malignant multiple lymphoma, infective lymphoma, lymphosarcoma (Virchow), malignant lymphosarcoma, lymphogenic diathesis, lymphatic cachexia (Mursick), lymphatic tuberculosis or Sternberg's disease, multiple sarcoma, recurrent fever (Rückfall) or Ebstein's disease, desmoid carcinoma (Wagner, Schulz), pseudoleukocythemia, pseudoleukemia (Wunderlich, Cohnheim), pseudoleukæmia infantum or von Jaksch's disease.

In therapeutics it is a recognized truth that the amenability of a disease to remedies is in inverse ratio to the number vaunted for its cure. Correspondingly, it might be said that the less known about the pathology of a condition, the greater the array of its appellations; and we have here a typical illustration of this fact.

Although, on the whole, the employment of eponyms in science is greatly to be deprecated, this is a case in which the distinguishing of a disease by the name of a man is, for the present, desirable. When the profession is fully persuaded as to the essential nature of this malady, a name will doubtless be created for it that will meet with general and deserved approval. Until then it is best to call it by the title that heads this section, for it commits one to nothing but the honorable recognition of the valuable work of an original and able physician.

What has thus far been said cannot raise high hopes of the reader's discovering anything satisfying in what follows. But it is worth while to know the principal opinions entertained at the present time upon this tantalizing and most difficult problem, and to gain some appreciation of the lines along which investigation particularly needs to be cultivated. Cases of Hodgkin's disease are not common; and, therefore, it is all the more important that every surgeon should study minutely all the features of every case of his that seems to belong to this class. Only by extensive collective investigation are we likely to attain the truth.

The clinical history of a typical case is as follows: The patient, usually a male and less than thirty-five years old, notices on one side of his neck a swelling, which is plainly composed of hypertrophied lymph nodes. After a time a similar enlargement appears on the other side of the neck, and subsequently there is involvement in turn of the nodes of the axillæ, of the groins, and of the thoracic and abdominal cavities. If the increase in size is rapid, the masses are soft; if slow, they are somewhat hard—the difference in consistency depending upon the augmentation of the cellular elements in the one case, and of the fibrous framework in the other. The nodes near the surface do not adhere to the skin, and in all situations are discrete for a variable time; but they finally blend, being fused together by the development between them of lymphoid tissue, which, though hardly appreciable in health, has participated in the change that has affected the lymphatic tissues universally. The disfigurement may be extreme: the neck seems invested in a thick collar, which presents two creases extending from side to side; the armpits are no longer cavities, but are filled to overflowing with the nodular masses;

the inguinal regions bulge enormously; while the growth of the nodes at the root of the lungs and in the mediastinum by their pressure cause dyspnea and cough. The spleen steadily enlarges by increase of its lymphatic constituents. Meantime the tumors are not painful or sore, and show no tendency toward caseation or the formation of pus; but the patient, who was at first somewhat anemic, has become very pallid, weak, emaciated, and cachectic. He suffers occasional attacks of slight fever, easily gets out of breath, loses his appetite, has indigestion, headache, and vertigo. His limbs become edematous, the serous cavities fill with dropsical effusions, diarrhea sets in, and he dies of complete exhaustion. Sometimes the disease kills through the local effects of the tumors pressing upon vital parts long before the constitutional effects have reached the limits above rehearsed.

Fig. 489.—Hodgkin's Disease (Matas).

The blood shows a diminution of all its constituents, but there is not a marked disproportion between the red and white corpuscles. The hemoglobin is much decreased. Cultures from the blood and from the excised nodes are sterile, and animal inoculations give negative results.

Investigators of equal standing contend, on the one hand, that Hodgkin's disease is primarily tuberculous, and, on the other, that it is sarcomatous. One can easily understand that, with the pronounced cachexia present in advanced stages and the consequent lessening of resistance, there is great liability to the invasion of the nodes by tubercle bacilli; but the detection of tubercles in the nodes is far from proving that tuberculosis was the original trouble. The behavior of the tumors is unlike that which is characteristic of sarcoma: there is no tendency of the tumors to invasion of adjacent parts or even to extension from their proper capsules.

At present the weight of evidence seems to favor neither the tuberculous nor the sarcomatous hypothesis, but rather the theory of a specific pathologic process of unknown origin and nature, which puts the disease in a class entirely by itself. The most reasonable conclusions appear to be those of Reed, and are here substantially quoted:[24]

The term Hodgkin's disease should be limited to the designation of a clinical and pathologic entity, of which the main features are painless, progressive enlargements of the lymph nodes, usually starting in the neck, and without the blood changes of leukemia. The growth presents a specific histologic picture, not a simple hyperplasia, but changes suggesting a chronic inflammatory process. The microscopic examination is sufficient for the diagnosis; but confirmation of the decision may be had from the negative results of an inoculation. Eosinophiles are usually found in great numbers, and their presence strengthens the diagnosis.

A dozen years ago[25] I expressed the opinion that possibly our then recently acquired knowledge of the varieties of leukocytes would help us to an early diagnosis by a microscopic examination of the blood, and that the whole subject needed to be studied afresh from this point of view. There is still ground for this opinion; and the solution of the mystery of causation may yet be found in this direction.

In making the diagnosis the possibility of confusing the disease with tuberculosis, sarcoma, lymphadenitis, and leukemic hyperplasia must be kept in mind.

Treatment.—The results of treatment are not cheering. Removal of all the affected nodes very early in the disease presents perhaps a possibility of cure; but recurrence must be expected. Operation is certainly justifiable to give relief of pressure-symptoms, and thus render the remnant of life less miserable. Serum-therapy has disappointed the hopes that were raised when it was first exploited. The *x*-rays have been tried in a purely empiric way, and are far from established as a valuable agency. All observers are agreed upon the endeavor to support the strength with nutritious food and tonics, and there is considerable testimony to the value of arsenic. It is not claimed that many cases are cured by this drug, but it is thought that some deference of the fatal result and some palliation of the symptoms are effected by it. Probably the initial dose would best be small, and a gradual increase made in the daily amount, until very large doses are taken, the original dose being then resumed, and the process repeated. The injection of arsenic into the growth is recommended—a drop of the liquor potassii arsenitis daily being thrown into the tumor in different places.

SARCOMA OF LYMPH NODES.

Sarcoma sometimes occurs as a primary affection of the lymph nodes. The tumor usually includes a group of nodes, is smooth, movable, painless, and enlarges rapidly. The capsules of the nodes are involved, and the adjacent parts are invaded or surrounded by the disease. Metastasis to internal organs may occur rather early. When the tumor is cervical, the windpipe and gullet may be fatally compressed. The late stages may be marked by perforation of the skin, hemorrhages, and suppuration.

The blood-picture in the disease is still undetermined. Rarely does the patient survive eighteen months. The diagnosis is difficult. If the

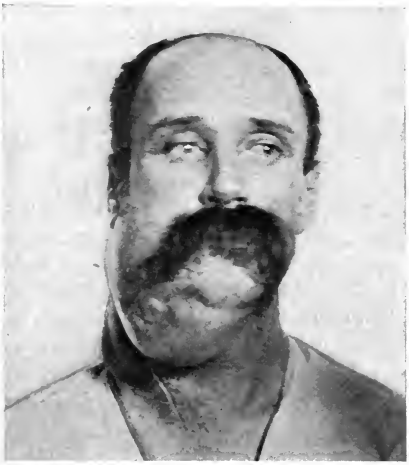

FIG. 490.—SARCOMA OF LYMPH NODES OF NECK (W. B. Coley).

case is seen very early, ablation may prolong life; but the majority are doomed to a speedy termination in death.

CANCER OF LYMPH NODES.

Cancer, very common as a secondary disease of lymph nodes, rarely affects them primarily. It is to be diagnosticated and treated along familiar lines

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CHAPTER XXX.

SURGERY OF THE SKIN AND ITS APPENDAGES.

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Comedones are the small yellowish or black bodies composed of modified horny cells, inspissated sebum, lanugo hairs, and organisms filling the orifices of the sebaceous glands. The affection is mainly one of adolescence, appearing at puberty in both sexes, usually coincident with acne, and is due in a measure to the physiologic hyperkeratosis common at this period. Occasionally it is met in young children or in old people. Other etiologic factors are anemia, dyspepsia, constipation, menstrual disorders, seborrhea, and trades, as working in tar, paraffin, and chlorin.

Their usual sites are the face, neck, chest, back, and rarely the genitalia. They are discrete, exceptionally grouped, from a pin-point to a pea in size, the latter being known as giant comedones.

The **symptoms** are purely objective. By pressure and resulting infection the comedo may cause inflammation of the gland with subsequent pustulation. After expression slight pits and scars may result. A combination of comedones and papules, nodules, or pustules in all phases of development make up the clinical picture of acne vulgaris. The eruption is generally confined to the face, but may appear on the back and chest.

Treatment.—If persisted in, the free use of soap and water with expression of the comedones, followed by ointments or lotions containing sulphur and local antiseptics, as in acne, will cause their disappearance. The general condition may be at fault and should be corrected according to the indication.

Milium.—A milium is a hard, pearly white or yellowish body, situated below the epidermis and projecting slightly above the level of the skin. Milia appear singly or in groups, commonly about the eyelids, cheeks, temples, and rarely the genitals. Pin-head in size or larger, without a visible opening, they are encountered most frequently in young adults, but may, however, be congenital about the lids and temples of the new-born, or may develop past middle life in groups on the lids.

Histologically, a milium is a superficial horny cyst taking its origin in the sebaceous acini or lanugo hair-follicles. Its layers have a concentric arrangement, and Robinson contends that there are two kinds: one consisting of "miscarried embryonic epithelium from a hair-follicle or from the rete," with neither fatty epithelium nor a duct; the other with a duct, being in reality a deep-seated comedo.

They persist for a long time and disappear spontaneously, or sometimes calcify or undergo colloid degeneration.

Treatment.—The lesions are readily removed by means of a curette, milium needle, or bistoury, or by electrolysis with the needle attached to the negative pole of a galvanic battery. The most commonly employed procedure is to puncture the milium with a small knife and express it with the blunt side of a curette.

Sebaceous Cyst.—A sebaceous cyst is a tumor resulting from retained sebum. The scalp, face, neck, and back are the usual sites, but they may be found on the genitals and trunk and even where sebaceous glands do not occur normally, as the palms, soles, floor of the mouth, and in the anterior chamber of the eye after wounds. A similar tumor in connection with the Meibomian glands of the lids is known as *chalazion.*

In size they range from a millet-seed to an egg or larger, and they may be globular or hemispheric, with or without a recognizable duct opening; if the former, the tumor is more apt to be flattened. They may be single or exceedingly numerous, movable or fixed. The integument over them is normal in color and smooth, or white if distended and red if inflamed; the consistency depends on the character of the contents. They grow very slowly and ordinarily persist indefinitely, but calcareous and atheromatous changes are common. Not infrequently they break down and ulcerate.

Török, Chiari, and others claim that the majority are really dermoids, but the view most generally accepted is that they are retention cysts. The wall is made up of connective tissue lined with epithelium, and the secretion, chemically altered, is fluid, semisolid, cheesy, or purulent.

Treatment.—Inflammation and suppuration may terminate in a permanent cure if the entire lining is destroyed. If not, suppuration continues, the fungating granulation tissue suggesting a carcinomatous transformation. A cyst that has never been the seat of an inflammation is easily enucleated by making a linear incision above it, care being taken to remove the sac in its entirety.

Molluscum contagiosum is the name given to small sessile or pedunculated white or pinkish tumors having a central umbilication. These growths occur in both sexes, but more frequently in children and among the poor. Their contagious character has been demonstrated clinically and experimentally, but the infectious agent is still unknown. Epidemics have occurred in children's asylums and in pediatric wards of hospitals, and their dissemination by scratch-marks has been observed. They are probably parasitic in nature, and various organisms, among them coccidia and gregarines, have been assigned as exciting causes. Similar growths have also been met with in fowls and pigeons.

The sites of predilection are the face, neck, breast, and genitals, although they may occur anywhere on the trunk and extremities and cases have been seen where hundreds were distributed over the body. They may be from pin-point to pea-sized or larger, a single tumor in the occipital region as large as two fists being on record. In their incipiency the tumors may be scarcely distinguishable from the surrounding skin, but they have a small opening through which the creamy contents can be expressed. As they grow larger they become hemispheric, flat or pedunculated, and mushroom like.

Microscopically, the growth is due to a hyperplasia of prickle cells which are arranged in a lobular fashion, the periphery of each lobule being composed of a layer of basal cells (Fig. 491). The whole tumor is surrounded by a fibrous capsule, septa of connective tissue passing

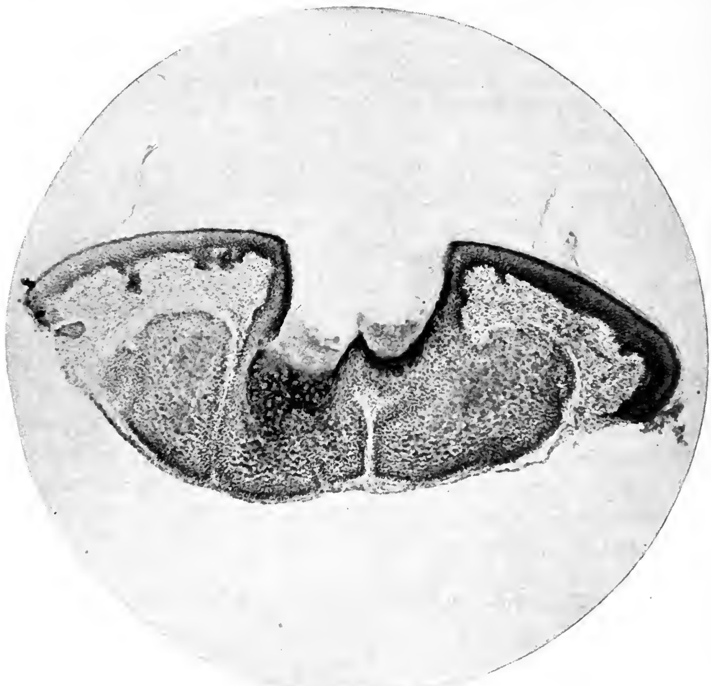

FIG. 491.—MOLLUSCUM CONTAGIOSUM (Spencer, 1 inch. Zeiss comp. ocular, 4). Section through small tumor.

between the lobules to support the blood-vessels. The nuclei of the cells gradually disappear from the periphery to the center, where are found the fully developed molluscum bodies, which have been interpreted as parasites, cell degenerations, colloid or hyaline masses, and keratin. The last view is probably correct.

The prognosis is favorable, many disappearing spontaneously in several weeks or months, but all cases should be treated on account of possible contagion.

Treatment.—The tumor can often be removed by curettage or pressure between the fingers, touching the base with a nitrate of silver stick or with the end of a match dipped in acid nitrate of mercury or tincture of iodin.

Dermatitis venenata is an inflammation set up by external irritants belonging to the vegetable, mineral, and animal kingdoms.

Susceptibility, concentration of the active principle, and the length of exposure are important elements in the production of one or several lesions, as erythema, wheals, papules, vesicles, pustules, bullæ, or gangrene. They may be called forth by the bites and stings of insects, dyes in clothing or cosmetics, articles used in trades and manufactures, plants, and medicinal agents.

Among the plants, rhus venenata (poison oak) and rhus toxicodendron (poison ivy) are the most frequent in this country. The parts generally affected are the face and hands or regions which may be touched by the latter. The symptoms usually develop within a few hours after exposure, and consist of erythematous patches and vesicles, swelling, and intense burning and itching, but in individuals with an idiosyncrasy severe grades of dermatitis are not infrequently met with.

Of the irritants used in medicine, the commonest are iodoform, mustard, turpentine, cantharides, croton oil, mercury, chrysarobin, arnica, and orthoform.

Treatment.—Keeping the parts covered with cloths saturated with a solution of equal parts of black-wash and lime-water or a solution of subacetate of lead will reduce the inflammation and give relief. In ivy poisoning aristol, as a dusting-powder or in watery suspension, sometimes brings about a prompt subsidence of the itching and other symptoms. I have successfully used the following formula in the various forms of dermatitis venenata:

℞.	Phenol	2 (ʒss)
	Zinci oxid.	
	Calamin. præp.	āā 10 (ʒiiss)
	Glycerin	15 (℥ss)
	Liq. plumbi subacetat. dil.	60 (℥ij)
	Aq. rosæ	q. s. 200 (℥viss).

Sunburn.—The majority of cases are those of burns of the first degree, an erythema limited to the exposed parts, with desquamation after some hours or days and slight pigmentation. Rarely there is vesicle formation, and a case in which a violent inflammation went on to gangrene has been reported. Sometimes there is an accompanying conjunctivitis, and if the burn is intense, an extensive fever may be present, or in children, delirium and convulsions. Bowles has shown that the burn is due in all probability to the chemic rays.

Treatment.—Ungt. aq. rosæ, dusting-powders, calamin and zinc lotion, or aluminum acetate solution. As prophylactic measures, brown veils and inunction with simple ointments are to be advised.

Dermatitis Gangrænosa Infantum.—This eruption occurs in anemic infants and young children, either spontaneously or subsequent to vesicular or pustular disease, as varicella, vaccinia, and measles, but scarlet and enteric fevers, tuberculosis, and syphilis are also mentioned as antecedent conditions. Various microörganisms have been found, but no conclusion as to their relationship has been reached. The initial lesion, a vesicle or vesicopustule on an inflammatory base with a pustular border, soon becomes covered with a crust underneath which ulceration takes place. This may enlarge by peripheral extension, or similar areas coalescing may result in an ulcer from one-half to several inches in diameter. Coming on during the course of the exanthemata, the usual sites of those maladies are the parts affected by the gangrenous process, but when it appears independently, the buttocks and thighs especially are involved. The constitutional disturbance corresponds with the severity of the cutaneous affection, new lesions of which continue to appear for days or weeks or longer.

Gangrenous Dermatitis.—See Vol. I, Chapter VIII.

The *prognosis* is serious in very young children with numerous lesions or septic complications, but many recover.

Treatment.—Tonic and hygienic measures should be carried out. Quinin, sulphocarbolate of soda, and opium have all been recommended. Locally, antiseptic applications of chlorinated soda solution, of corrosive sublimate 1 : 2000, boric acid, or 5 to 10 per cent. ichthyol solutions or ointment or aristol powder.

Besides diabetic gangrene and Raynaud's disease, two forms of **sphaceloderma** are met with in adults, the one having for its etiology typhoid, malaria, scarlet fever, measles, varicella, variola, syphilis, or local infections, phlegmonous erysipelas, noma, etc., in which the lesions are not unlike those found in infants. The other form occurs in the neurotic, hysterical, and malingerers. Some authors believe that these latter are all cases of self-infliction, since the subjects are young and hysterical women and neurotic and hysterical men. The closest observation failing to detect the artificial nature of the eruption, a neurotic theory is proposed by others. In some cases a very trifling injury will initiate the outbreak, while others have been produced by the mineral acids or alkalis. The two types present no essential differences in their course, and all grades from a simple inflammatory macule to necrosis may be seen, cicatrization taking place when the sphacelated tissue is cast off. The systemic symptoms are generally mild. The course is often a long one, but the prognosis is usually favorable.

Treatment.—If the underlying cause can be determined, treatment should be directed to it. Locally, the removal of the gangrenous sloughs is often found necessary; otherwise, antiseptic dressings are all that is required.

A furuncle or boil is an acute staphylogenic inflammation about the skin appendages, terminating in necrosis and suppuration. The causative agent is usually the staphylococcus aureus. The organisms may remain latent in the upper layers of the epidermis for some time, when sudden irritation will produce auto-infection. Predisposing causes are improper hygiene and diet, diabetes, nephritis, intestinal intoxication, and nervous depression. Other influences are professions, trades, localities, seasons, pruritic affections in which scratching produces inoculation, the application of plasters, moist dressings, etc.

Boils may be single or multiple, coming out in successive outbreaks to which the term furunculosis is applied, the condition persisting for months or years if untreated. Any part of the integument may be attacked, but the neck, back, axilla, face, buttocks, genital region, and legs are favorite locations. The neighboring lymph nodes are enlarged and sometimes there is constitutional disturbance.

A typical boil begins as a small nodule, accompanied by burning or tension. In two or three days this has developed into more or less of a conical swelling, which is red, hot, and painful, its apex capped by a seropurulent vesicle and usually pierced by a lanugo hair. As it enlarges the center undergoes necrosis, and from the opening pus and the "core" are discharged; although the latter may not be separated for a day or two longer, pain is relieved at once. The cavity granulates, leaving more or less of a scar. If suppuration and resolution do not take place, the "blind boil" results.

Verneuil describes a variety having its origin in a sweat-coil, which differs from the ordinary boil in being at first subcutaneous, involving the skin only as it approaches the surface. As a rule, there is no core and discharge takes place for a longer or shorter time, leaving an abscess cavity which is often quite large. The most frequent situations for this type are the axillæ, genito-anal region, nipples, and arms, but they may form wherever there are sweat-glands, except on the soles.

The **prognosis** of solitary boils is good, but maltreatment may lead to lymphangitis, adenitis, and pyemic metastases. When situated on the face, the danger of meningitis must not be lost sight of. If multiple, they debilitate or aggravate an already depressed general condition, and in diabetes the course is always more serious.

Treatment.—An endeavor may be made to abort a furuncle by the application of 25 per cent. ichthyol in water, mercurial or carbolic acid plasters, or by touching the center of the lesion with the Paquelin or galvanocautery point. When this is no longer feasible, suppuration may be hastened by the use of hot bichlorid compresses, followed by a crucial incision under cocain or ethyl chlorid. In Germany Bier's[1] method of hyperemia induced by suction, with or without a slight incision, is in favor. It is claimed to be superior to other modes of treatment in that healing takes place in furuncle in five days and carbuncle in ten to fifteen days.

For recurring furunculosis Wright[2] recommends a vaccine from staphylococcus albus and aureus cultures. Surface disinfection with chlorid of lime and carbonate of soda may prevent auto-inoculation. Tonics, stimulants, and other treatment directed toward the general condition of the patient may be indicated.

Carbuncle.—A carbuncle differs from a furuncle in extent and severity, with probably a superadded infection with streptococci. It is seen most frequently in persons over forty, but occasionally in young people, especially about the lip and face.

The lesion begins as a circumscribed infiltration which burns and itches. Extending, it becomes dusky red, protrudes above the surrounding level, and soon acquires a board-like hardness. Its development is more rapid than the furuncle, and within a few days it is covered with pustules, which, after one or two weeks, soften, discharge pus, and leave numerous sieve-like perforations leading to the gangrenous mass. The constitutional disturbance is often marked, the affection being ushered in by a chill and fever, frequently followed by profound depression, but as the openings form, the symptoms ameliorate. If not removed, the necrotic tissue is gradually eliminated, leaving an irregular ulcer which fills up with granulations and cicatrizes in the fourth week.

The usual sites are the nape of the neck and the back or regions where the skin is thick. In size they vary from a quarter of a dollar to an area involving the entire back.

The process is similar to that in furuncle, but is situated deeper. Some authors believe that there are multiple points of infection, but Warren[3] explains the formation on anatomic grounds, the infection travelling along the columnæ adiposæ, pustules forming about the hair-follicle and laterally spreading along the blood- and lymph-vessels until all the cutis becomes involved excepting a thin layer above.

The **prognosis** should be guarded in old people and in individuals with diabetes or Bright's disease. Auto-inoculation may take place at the periphery and prolong the course of the malady, or it may be complicated by a septic phlebitis, embolism, septicemia, or pyemia. Carbuncles of the head and face are always serious on account of the danger of meningitis or pyemia, and proper treatment should be begun early. The mortality of such cases is about 50 per cent.

Diagnosis.—The constitutional disturbance, extent, and later the multiple openings differentiate it from furuncle. It might possibly be confused with anthrax, but the sharply defined inflammatory reaction of the latter is soon followed by vesicle formation and localized surface gangrene, while the discovery of the bacillus anthracis would soon clear up the diagnosis.

Treatment.—This consists in supporting measures, including alcohol and tonics, an easily assimilable diet, and morphin to relieve the pain. Hot applications will hasten the process. Early multiple incisions should be made, the necrotic tissue being removed by curette and scissors. The best antiseptic application, in my own experience, is chlorinated soda solution, diluted in eight or ten parts of water and changed frequently. After discharge takes place this solution may be employed freely by means of a douche or syringed into the slough. Riedel's[4] method consists of the total extirpation of the affected tissue from the underlying fascia under anesthesia. In the debilitated, where hemorrhage would be serious, the Paquelin cautery may be used instead of the knife. This method is, of course, not applicable in extensive cases, owing to tissue defect and hemorrhage, but in those which are suitable for this procedure the effect is prompt, fever and pain disappearing rapidly. Moore[5] strongly urges radical treatment when the disease is situated on the upper lip and face. A free incision into and curettage of the necrotic area are followed by swabbing with 95 per cent. carbolic acid for a minute and then alcohol, after which the wound should be packed with iodoform gauze and a surgical dressing applied. In any instance, whatever the mode of treatment, precautions should be taken against reinfection.

Burns result from contact with dry heat, acids, or caustics; scalds from hot liquids or steam. Clinically, the results are about the same in both.

It is customary to divide burns into three grades: the first degree, characterized by a simple erythematous inflammation, sometimes followed by desquamation; the second degree, an inflammation with vesicles and bullæ, which may not appear until twelve or twenty-four hours after; and the third degree, in which there is partial or complete carbonization of the skin or underlying structures, or sloughing following secondary inflammation, with a dry or moist eschar.

Symptoms.—Locally, any stage may be present from an erythema to charring, the pain being commensurate with the lesion, but it is less complained of when the skin is destroyed *in toto*. The general symptoms may range from a slight pyrexia in a burn of first degree to profound shock in severer forms, followed by reaction, and this succeeded by congestion or inflammation of the viscera, as pneumonia, pleurisy, meningitis, peritonitis, duodenitis, etc. The blood shows loss of serum and rise in specific gravity, but after twenty-four hours it may be normal again. Leukocytosis is sometimes very marked, though of short duration, and the red cells are in various stages of degeneration. The urine has a high specific gravity, contains a good deal of albumin, blood, and casts of all varieties; is secreted but sparingly, and is toxic to animals.

Death occurring a few hours after reception of a burn is in all probability due to shock;[6] within the first day or two, to intoxication by poisons derived from heat-changed albumin molecules, giving rise to the visceral inflammations enumerated. After two or three weeks, while the poisons generated have not been without their deleterious effect, death results rather from the septic or other complications which may supervene, as tetanus, arthritis from invasion of the joint by ulceration or sloughing, hemorrhage from ulceration of large vessels, or exhaustion in the early or late stages. Dyspnea from edema of the glottis may necessitate tracheotomy to avert impending death.

Pathology.—That the intoxication results from the disorganization of albumin is accepted by most authors, but there is no unanimity among investigators as to the exact chemic nature of the poisonous product (peptotoxin, pyridin base, member of the muscarin group, etc.). According to Spiegler,[7] the toxin is one of the by-products of overheated albumin, his explanation of mild symptoms and even recovery in extensive burns usually lethal being that absorption is hindered, or through longer action of the high temperature the poison itself destroyed. Pfeiffer,[8] from his experiments, believes that it bears some resemblance to snake-poison and nucleoproteids. Wilms[9] is of the opinion that in burns of the third degree death is due to an intoxication with decomposed products of albumin, and in those of the second degree to loss of blood plasma. Others again look upon shock as the immediate cause of death.

In animals, post-mortem, have been found parenchymatous degeneration of the viscera, emboli of the capillaries and larger vessels, with focal necrosis, blood and urinary changes. Weidenfeld suggested that the mass and not the extent of the burn causes death.

Prognosis.—Areas involving more than two-thirds or even one-half of the body are fatal, and often when more than one-third is implicated death follows. A fatal outcome is more apt to occur in the very young or the old or in alcoholics. Relatively small areas from very hot liquids often result in fatal issue in children. An ominous sign is recurring vomiting. As the symptom-complex appears within the first forty-eight hours, if patients survive this time the prognosis is more favorable. In a large percentage of cases necropsy reveals ulcer of the stomach or intestine, death being due to hemorrhage or peritonitis.

Treatment.—For combating shock the use of adrenalin, saline injections, etc., should be employed. Burns of the first degree require no treatment except dusting with bland powders and lotions, as bicarbonate of soda, carron oil, and aluminum acetate solution.

In burns of the second degree, the blebs should be punctured at the most dependent part and aluminum acetate solution or 1 per cent. boric acid dressing, Squibb's compound alum powder, or silver foil applied to the raw surface. The dressing should be removed once daily; twice if secretion is abundant. A rise of temperature in the absence of complications calls for more frequent removals. This should be continued until epidermization is complete, which may be hastened by silver nitrate and skin-grafts. In extensive burns, where bandages cannot be applied, Hebra's continuous water-bath is especially valuable; in cases with pronounced suppuration, absorption is prevented and fever diminishes or disappears. Sneve[10] is in favor of the open method of treatment, *i. e.*, the disuse of occlusive dressings and reliance on strict cleanliness and perfect drainage for healing of injured surfaces.

In burns of the third degree all necrotic fragments of tissue and clothing not firmly adherent should be removed. When extensive, prolonged immersion in hot baths affords relief to pain, and in the early stages prevents collapse. When the lesion is limited, it should be treated on general surgical principles by local disinfection and the removal of sloughing tissue under anesthesia or otherwise. Burns over large vessels should lead the surgeon to great watchfulness, and instructions should be given to the patient or attendant as to measures to prevent hemorrhage. Deformities resulting from cicatrices with functional impairment should be guarded against or limited by asepsis, as far as practicable, and by early skin-grafting by Thiersch's method. There should be early movements of the involved parts and regard should be paid to posture during sleep. Cicatrices are apt to ulcerate, especially in the poorly nourished, and repeated ulcerations may become the seat of carcinomatous changes.

The effect of carbolic acid on the skin is neutralized by the use of absolute alcohol, and that of caustic alkalis by vinegar or some other mild acid.

Constitutional Effects of Cold.—Primarily there is a period of stimulation with acceleration of the circulation and a sense of exhilaration. This is succeeded by depression with pain, torpor, restlessness, coldness, numbness, and an overwhelming desire to sleep, which, if succumbed to, ends in death. Muscular contractions, particularly of the muscles of the neck, are sometimes seen, together with symptoms like those of catalepsy. In sudden and progressive chilling the fatal result may be due to cerebral anemia; in cases of slow and continuous chilling, to cerebral congestion, and in sudden reheating, to embolism. In partial congelation the usual cause is congestion, but occasionally it is anemia, both brought about by capillary embolism.

Treatment.—The patient should be placed in an unheated room and rubbed with cold wet cloths and then placed into a bath of 16° to 18° C. (60.8° to 64.4° F.), which should be very gradually, *i. e.*, within two to three hours, raised to 30° C. (86° F.). Artificial respiration may be necessary, and ether or camphor is to be administered subcutaneously. As soon as patient can swallow, alcoholic stimulants are to be given. The extremities are to be wrapped in cold wet cloths, and for the severe pains, Bergmann and Reyhen recommend their suspension.

A **frost-bite** is the local effect of cold. As in burns, the division into three degrees of freezing is made, viz., the erythematous, bullous, and escharotic.

The redness, numbness, and tingling which follow exposure to intense cold are succeeded by loss of power, usually commencing in the fingers and toes, and loss of sensation, the parts becoming anemic and cold.

In the second degree the skin is red or bluish and covered by blebs with clear or hemorrhagic contents. If the epidermis only is lifted up, there is quick and scarless healing, but in the majority of cases the deeper tissues are involved.

In frost-bites of the third degree there are blebs and crusts and they terminate in mortification of the affected tissue. Parts hopelessly frozen are at first anemic, cold, and insensible, but after reaction sets in they become swollen and discolored or they shrivel up and contract. It is not unusual for the part to show no change for some days and then become blue or black; a line of demarcation forms and the tissue sloughs off.

Prognosis.—Skin that is sensationless for twenty-four hours is to be looked upon as "dead." Sonnenburg warns against the diagnostic needle prick, as it may lead to deeper gangrene.

Treatment.—Reaction must be gradual. The room should be of low temperature, and the part immersed in ice water, making gentle friction or rubbing lightly with snow. When the temperature is normal, stimulating friction with soap liniment, alcohol and water, and spirits of camphor, with elevation of the parts. The room may be gradually warmed and the parts exposed, then covered with cotton. As reaction progresses stimulant and warm drinks may be cautiously administered. If excessive reaction takes place, evaporating lotions of alcohol and water may be used. Where a large surface is frozen, prolonged immersion in a bath may be employed after reaction has been established. When gangrene is present, surgical intervention is called for.

Erythema pernio, or **chilblain,** occurs in individuals with a feeble circulation or in the anemic or strumous, though healthy young people are liable. The parts usually attacked are the hands and feet, especially the heel and borders of the latter, but any of the peripheral parts, as the ears and nose, may be affected.

The areas are bluish or purplish red, swollen, cold to the touch, tender, itching, and burning. Neglect and friction will produce severer grades of inflammation, with vesicles, bullæ, pustules, and ulceration or even gangrene, with or without the formation of bullæ. There may be a favorable termination or fatal septicemia may supervene.

Treatment.—This should be preventive by protecting the hands and feet, wearing warm clothing, and by exercise and the administration of tonics. Locally, immersion of the affected parts in hot saturated solution of alum relieves the venous congestion and itching. In severe cases heating too rapidly or overheating should be prevented so as not to restore a too rapid reaction. A strong faradic current ten minutes thrice daily, or the electric bath ten to fifteen minutes daily, is beneficial. In ordinary cases balsam of Peru, vasogen-iodin, or 10 per cent. ichthyol ointment rubbed in is all that is required. When there is ulceration, antiseptic dressings should be applied.

Corn.—A corn differs from a callosity in having a central peg. There are two varieties, hard and soft, the latter forming where the surfaces are opposed and heat and moisture are greater. Corns are seen generally on the toes from improperly fitting shoes, but similar multiple lesions of the hands have been reported. A secondary small bursa which may communicate with the underlying joint or tendon-sheath is not infrequently found under large corns. After cutting a corn, severe or even septic cellulitis, resulting in amputation or even death, may follow infection of this small bursa, if suitable treatment is not promptly begun.

Treatment.—The wearing of suitable shoes is the first essential. The soft variety should be protected with cotton upon which may be applied an ointment containing mercuric nitrate. The hard should be softened with a 10 per cent. caustic potash solution or macerated with an oil dressing or warm water.

The following formula also affords relief:

℞	Acid. salicyl.	1	(gr. xv)
	Æther	2	(ʒss)
	Ext. cannabis indicæ fld.	0.5	(gr. viiss)
	Collodii	8	(ʒij)
	Alcohol	1	(♏xv).

Or a more rapid method is to curette and then apply salicylated plaster. Bursæ and fistulæ are rapidly cured by removing with scissors or a pointed knife, by complete excision of the inflamed area, or by the use of the galvanocautery. If the bursa communicates with a joint, the strictest asepsis must be observed during and after treatment.

Cornu cutaneum, or **horn,** is a protuberance of horny structure, variable as to shape and size.

Horns are rare, but they may develop on the scalp, forehead, temples, eyelids, nose, the extremities, male genitals, and on the trunk. Old age is predisposing, and they are uncommon before forty. Met with more frequently in women than in men, the majority have their starting-point in a sebaceous cyst or atheroma, others in warts or scars, or, again, they may arise spontaneously. They have had their origin in toe-nails which have become altered, and they are sometimes found on the borders of epitheliomata. Among other factors of significance senile keratoma, psoriasis, simple genital vegetations, preëxisting phimosis, condyloma acuminatum, and syphilis have been given.

They give no symptoms except from their localization. They may be solitary or multiple, as many as 133 in a girl of eighteen having been reported, and of any size from three millimeters to thirty centimeters.

Their course is usually slow, and it is believed that epitheliomata develop in 12 per cent. They sometimes fall off spontaneously, but usually recur.

Treatment is surgical, and extirpation should be early and complete by excision of the base, or the horn may be removed and the base cauterized with zinc chlorid or the galvanocautery.

Wart.—A wart is a circumscribed hyperplasia of all the epidermic layers, varying in size from a pin's head to a small nut. The most familiar variety, verruca vulgaris, is met with chiefly on the dorsal surface of the fingers and hands, in the nail-fold, whence it may spread under the nail and on the mucous membrane of the mouth, to which it is sometimes confined. Growths of this type may be solitary or multiple, and come and go without any special reason. Modifications of the ordinary wart are verruca filiformis, a slender filamentous growth about the neck, face, and eyelids, and verruca digitata, found most frequently on the scalp, which is characterized by a division into finger-like processes extending nearly or quite down to its base.

Verruca plantaris is observed on the sole of the foot, one or more being present. It is very painful, may be the size of a pea, and is often mistaken for a callosity, from which it is to be distinguished by the pain on pressure and the tendency to bleed when the horny layer is removed.

Verruca plana, or flat wart, occurs in both the old and the young, its clinical features varying accordingly. Verruca senilis, mainly on the back and arms, is brown to black, sometimes itches, and may become papillomatous. The seborrheic wart, which is analogous, has a greasy scale and appears also on the backs of the hands. Keratoma senilis is an allied preëpitheliomatous condition which is seen on the face of elderly people, especially the nose and cheeks. In children and young people verrucæ planæ are small and situated on the face, especially the forehead, but sometimes on the backs of the hands. They may be slightly pigmented, discrete, or irregularly grouped.

Verruca acuminata occur about the male and female genitals as the result of irritating discharges or independent of them. They are to be differentiated from condylomata lata, which are always specific and are simply syphilitic papules modified by warm and moist localities.

Warts are probably contagious, but the pathogenic agent has as yet not been isolated. Successful inoculation experiments prove the incubation period to be a long one—from weeks to seven months or more.

Warts sometimes disappear spontaneously, and they will recur if their removal is not complete. Those which follow the prolonged use of arsenic internally or which develop on skin exposed to climatic conditions, as the so-called sailor's skin, will assume malignant characters, as will those produced by *x*-ray. It is, however, the extremest exception for the common variety to undergo malignancy,[11] but some forms of cutaneous epithelioma begin as a papillary outgrowth suggesting warts in appearance.

Treatment.—The best method is to freeze the part with ethyl chlorid and then thoroughly curette the growth. After the bleeding has stopped, it should be painted with pure carbolic acid, followed by the light application of nitric acid. When warts are small, no subsequent treatment is needed, but if large, suppuration occasionally takes place beneath the crust, in which case the latter should be removed and the area dressed antiseptically. When they are situated beneath the nail, after thorough curettage the base should be cauterized with the Paquelin or galvanocautery.

A **callosity** is a circumscribed thickening of the stratum corneum. The condition is usually acquired, occurring on parts exposed to intermittent pressure with counterpressure from an underlying bony prominence, as on the toes, sole, and heel of the foot from ill-fitting shoes, the palms and fingers from occupations, and other parts of the body from the friction of clothing, trusses, and belts. Lye and mineral acids or other chemically irritating substances and heat may produce it, the latter often giving rise to extreme cases; or it may appear spontaneously.

Callosities are dirty yellow to brown, their extent depending on the cause, being thickest in the center and passing gradually into the healthy skin. Epidermic markings are less distinct or lost, and tactile sensation is diminished. They may interfere with movement and may have painful fissures and become infected, giving rise to abscess, lymphangitis, gangrene, or erysipelas. Sometimes they are the seat of a hemorrhagic exudate, and hyperidrosis is often a concomitant symptom.

Treatment.—Removal of the exciting cause is frequently followed by spontaneous disappearance. Of greatest value are the salicylic acid preparations—a 10 per cent. solution in flexible collodion or the plaster. Nightly soaking in warm oil also softens the thickened epidermis, and in extreme cases it may be destroyed by the use of concentrated caustic potash; or, after shaving off the horny thickening, the modified papillary layer may be touched with the Paquelin cautery.

Vicious cicatrices result from the replacement of extensive losses of the integument by fibrous tissue, which, from its location, extent, adhesions, etc., produces more or less deformity or functional interference.

While any traumatism, specific or other ulceration or gangrene may give rise to them, burns are the most frequent cause of grave and complex deformities. The abnormality may be limited to the cicatrix itself by the persistence of color, exaggerated growth, or depression, especially about bony or articular suppurations and adherence to the underlying tissue. Or a deformity may be due to bands binding different members or parts of them together, as in the folds of flexion, palm of hand, etc. In burns of the neck and chest the chin may be drawn down (Fig. 492). Adhesions may unite different members to the trunk or the lateral surfaces of the fingers and toes. Cicatricial stricture of the various canals may be consecutive to burns, hot liquids or caustics, or syphilitic or other inflammation. The orifices, especially those about the face, mouth, nares, eyes, and ears, may be the seat of strictures, obliterations, ectropion, and deviations. Recurrent ulceration in scars leads to exuberant epithelial proliferation and sometimes to epitheliomata.

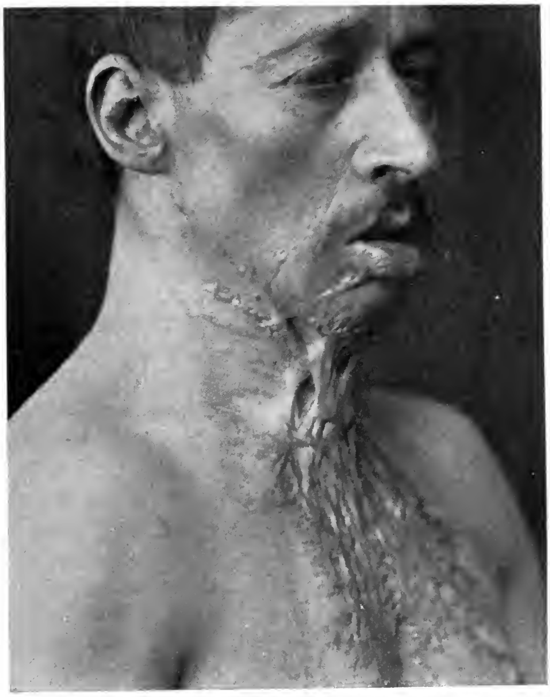

Fig. 492.—Cicatricial Contracture Following a Burn.
Italian, aged thirty-two years, burned six months before by gas-flame. Chin is partially immobilized by the dense fibrous bands which extend from it to the sternal notch.

Treatment.—*Prophylactic.*—Care should be given to attitude, the rule being to place the part in a position least favorable for approximation of the wound, as in large burns of the arm permanent flexion may be prevented by maintaining extension of the parts. In the neighborhood of the natural orifices where the opening is menaced, the introduction of a foreign body, as a drain, will maintain the opening or dilate it. If there is a tendency to exaggerate the orifice or produce an ectropion, the edges should be approximated, suturing if necessary. The curative treatment is divided into operative and non-operative. The former[12] includes compression for persistent redness; compression, scarification, or extirpation for hypertrophies; Gersuny's[13] method of injecting liquid vaselin into the cellular tissue under the cicatrix for depressed and nonadherent scars. It is not absorbed and keeps the skin elevated. Adherent scars are sometimes spontaneously liberated, but should be aided by douches, baths, massage, moderate exercise, and subcutaneous tenotomy, followed by mobilization to prevent production of deformity. If it reforms, a new section should be made, followed by grafts or Gersuny's method. Claude Martin's[14] treatment is based on the extensibility of cicatricial tissue. He employs traction and continuous pressure, never violence, supple scars forming and the parts returning to an almost normal position. Absorption of fibrous tissue can also be hastened sometimes by the x-ray.

The *operative treatment* comprehends—(1) incision, the bands being divided and the surfaces brought together in a direction opposite to that which the retracting bands had given them; they should be maintained in that position until the new cicatrix has lost all tendency to reproduce the deformity; (2) excision; (3) skin-grafts, epidermic or dermo-epidermic; (4) amputation may be necessary when the part is a hindrance to the patient. (See chapter on Plastic Surgery.)

Keloid.—A keloid is a connective-tissue growth in the corium arising spontaneously or after traumatism. The former is known as the true and the latter as the false keloid or hypertrophic scar. It is questionable whether this distinction is of much value, however, as the so-called spontaneous have been known to follow insignificant injuries.

The etiology is unknown. Their symmetry at times has suggested a trophoneurosis; others believe in a local infection, and Crocker[15] adds that the microbic origin is very plausible, as lesions following suppuration are particularly liable to be followed by keloid, and when the process is once started in a scar, old ones long quiescent become keloidal. Goldman views the disappearance of elastic tissue as the favorable moment for their development. Unna claims that those over the sternum and about the breast result from the scratching in a seborrheic dermatitis, and again it has been said that they are caused by pressure. They may appear at any age, but do so more commonly after adolescence; both sexes are liable. Certain individuals seem to have a special predisposition, and perhaps it is hereditary; it is a fact that the negro is more susceptible than the Caucasian, as are also the strumous.

For the spontaneous keloid the site of predilection is over the sternum, although it may appear anywhere, the face, however, being rarely affected. They are usually single, but their number may run into the hundreds. In general they are sharply defined and project above the healthy skin. They are freely movable and of variable shape—round, oval, or cylindric and flat or nodular. Often they have lateral prolongations extending into the neighboring tissues, which have been likened to claws. At times the growths are pedunculated. The surface is smooth or uneven, white, pinkish, or purplish if very vascular, and they are sometimes symmetrically distributed. Subjective symptoms may be entirely lacking, or there may be tenderness, pain, burning, or itching. Their position may cause great inconvenience, as when the tumor surrounds the neck or causes knobby contractures of the fingers and toes.

False keloids develop anywhere in a scar resulting from injuries whose nature may have been most trifling; thus they may follow piercing of the ears, prickly heat, acne or other pustules, vaccination, burns, bites, syphilis, etc. They are not limited to the scar, may attain quite large dimensions, and are difficult to diagnose from the spontaneous.

Some authors make a further differentiation between false keloid and hypertrophic scar, giving the latter appellation to cicatricial formation which is confined to the wound area, and it is said to occur only in septic wounds. There is then a simple hyperplasia and hypertrophy of the granulation tissue, differing from the others in that the fibers run in all directions.

Pathology.—The growth is situated in the central and lower portions of the cutis. It begins in the walls of the larger vessels, and when fully developed, is composed of dense collagenous bundles which are arranged for the most part parallel with the long axis of the tumor, ultimately compressing all the structures in their vicinity. According to Warren, the vessels are affected some distance from the keloidal growth.

Prognosis.—Usually only the deformity is complained of, but neuralgic pains may necessitate an operation. The growth is persistent and, as a rule, little influenced by treatment. Sometimes they undergo spontaneous retrogression without any interference. When removed, they invariably recur, although some cures have been reported. It is exceptional for them to ulcerate or acquire malignancy, but epitheliomata have followed recurring ulcerations in scar tissue (hypertrophic or otherwise), while sarcomata have been noted after keloidal growths.

Treatment.—Many writers advocate letting these growths alone, as there is a strong probability that the scar following the knife will undergo a similar change if surgical treatment is adopted. Goldman advises the use of the Thiersch skin-graft after extirpation to prevent their return. The best results are obtained from the use of the *x*-ray or of the rays after excision. Those who favor operative measures have had good results by making a very wide incision to get beyond the diseased vessels. Mincing up the tissue by linear incisions to divide the vessels as thoroughly as possible has been followed by improvement and even disappearance. Electrolysis and static electricity also have their adherents. Thiosinamin, for which much was claimed at one time, has not proved of value. Neither has the Finsen method been successful, keloid developing in several instances in patients so treated.

Malignant Disease of Scars and Ulcers.—Marjolin's ulcer, described by Marjolin over fifty years ago, and more recently revived by DaCosta,[16] is the designation applied to chronic ulcers which have undergone malignancy. Ulcerative lesions on any part of the body, scars from burns or other previously existing benign ulcerative process, and even unchanged and typical cicatricial tissue may degenerate in this manner. Analogous antecedent changes are lupus and syphilis, the latter preparing the way for many cancers of the oral mucosa. In old ulcers young epithelial cells often become buried in the granulation tissue, which may serve as a tumor matrix and assume active tissue proliferation at any time when the local conditions are such as to permit tumor formation. In lupus the change may take place on an active lesion or in the cicatrix, but usually it is an old lesion, which, however small, may serve as the point of departure.

I have had several cases under observation. In one, the ulceration from suppurating buboes of the groin underwent simultaneous carcinomatous change in both areas. In another from a burn there was an extensive ulcer covering two-thirds of the forearm which refused to heal after the application of the ordinary methods of treatment. The third, an ulcer of the leg, was the counterpart of the others, and the accompanying cuts (Figs. 493 and 494) show an ulcer of the thigh from a burn received forty years before, which broke down and healed several times, then finally developed into a squamous-celled cancer.

FIG. 493.—CARCINOMATOUS CHANGE IN CHRONIC ULCER.

Male, aged forty-six. City Hospital. Burn of hip and side of trunk when three or four years old. Has healed and broken down several times—now has ulcer 3 × 4 inches on hip, surface knobby, here and there islands and streaks of new epidermis. Biopsy showed typical squamous-celled cancer, sharply limited by dense mass of sclerotic tissue beneath.

In an ulcer undergoing malignancy the edges become elevated and hard, the granulations are larger, harder, bleed more readily than healthy granulations, and assume a warty character. There are often a great deal of pain and a foul bloody discharge; the neighboring tissue becomes indurated, owing to extension of the process, and after a time the regional lymph nodes are involved.

The *treatment* is necessarily that of epithelioma. In the early stages radiotherapy is of value.

Nævus is the term used for an embryonic growth of the skin originating from defects in fetal life. They may be congenital or appear after birth, sometimes not until puberty or later.

The most common variety is *nævus vascularis,* due to a congenital overgrowth of cutaneous vascular tissue, either capillary or venous. The former, seen about the head, face, and upper part of the body, is slightly elevated, bright red, the size of a quarter or smaller, and may remain stationary or disappear spontaneously, leaving no trace or slightly atrophic scars. Another form is the diffuse red *port-wine mark*, or *nævus flammeus*. The venous nævus is elevated, smooth, or lobulated, purple, soft, and compressible. Found chiefly on the lower portions of the body, some are turgescent, pulsating, or even erectile, and may be covered by hair.

Nævus unius lateris has usually a linear distribution, following the long axis of a limb or having a transverse disposition about the trunk. They are multiple lesions closely aggregated, giving the surface a warty

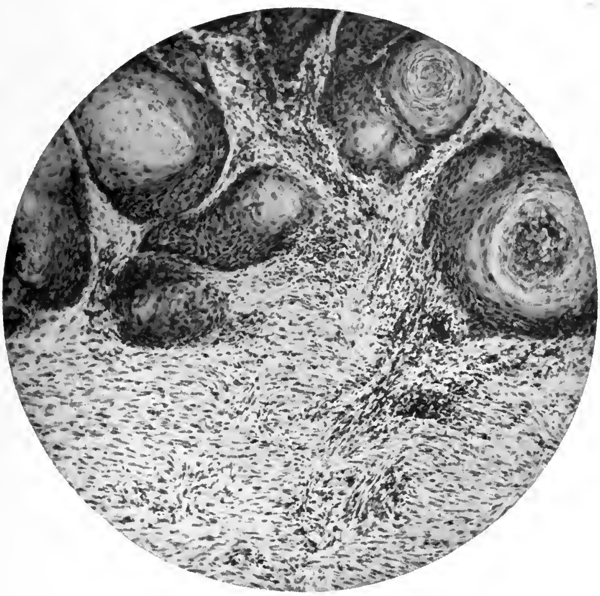

Fig. 494.—Epithelioma of Thigh after a Burn (Marjolin's Ulcer).
Spencer ½ inch, Zeiss comp. oc. 4. Showing sharp limitation of the epithelial growth by the sclerotic connective tissue beneath. The relatively benign course is probably explained by the resistance of this tissue.

appearance, and are sometimes not noticed until the first or second year of life.

Nævus pigmentosus or *mole* has subvarieties, as nævus spilus, which refers to an abnormal deposit of pigment only, either single or multiple, shading from brown to black and having often an extensive distribution, generally unilateral. Where the surface is uneven or papillary it is spoken of as nævus verrucosus; if covered with hair, as nævus pilosus, and if fat is present, it is known as nævus lipomatodes. White moles are identical with the pigmented except that they lack the color.

Pathology.—In addition to a deposit of pigment there may be hyperplasia of all the cutaneous structures. Raised pigmented or colorless moles are due to epidermic hypertrophy and groups of cells in the derma arranged in an alveolar manner, known as "nævus cells" (Fig. 495). It is disputed whether these cells are from the epidermis or from the endothelium of blood- or lymph-vessels.

Prognosis.—Degenerative changes are possible, and in the young slight injury may be followed by gangrene or necrosis. Late in life moles, if irritated,[11] are sometimes the starting-point of melanotic growths, especially on the foot. Malignant melanotic tumors are probably epitheliomata, which view is supported by Unna, Gilchrist, and others, while their endothelial nature has lately been reaffirmed by Johnston. Although reported, it is rare for epitheliomata to develop on moles in young adults. The prognosis of vascular nævi is favorable as to health and life; they usually persist, but seldom increase in size. Hemorrhage when it occurs is rarely dangerous.

FIG. 495.—NÆVUS PAPILLARIS OF THE THIGH.
Spencer 1 inch. Zeiss comp. oc. 4. Showing elongated and hypertrophied papillæ with characteristic nævus cells, a marked hyperkeratosis, and atrophy of the rete.

Treatment.—Nævi may be removed by the knife when the area involved is not too large. Caustics, electrolysis, the curette, and liquid air may be employed, but the removal should be gradual to minimize the scarring. Hot-water injections have been recommended. All irritation should be avoided because of the danger of malignant transformation. For vascular nævi thorough freezing with liquid air is often followed by a cure, with only a slight atrophic scar. Pigment spots and moles may be treated in the same way.

Von Recklinghausen's Disease.—This is characterized by the following clinical features: patches of pigmentation, multiple molluscous tumors, and pseudo-neuromata distributed along the course of a branch or an entire plexus of nerves.

Etiology.—The disease usually appears in childhood, but is sometimes congenital or may be delayed until puberty or late in life. It preponderates among men, is obscure in origin, but in all probability is the result of a fetal defect, and heredity apparently plays a rôle in that two or three successive generations are afflicted. While not true of all, a number of subjects show a retarded development, some malformation of the skeleton, or a stunted physique. Traumatism seems to be of influence in their production, or, as von Recklinghausen suggests, in their localization.

Symptoms.—The molluscous tumors vary in size from a pin's point to an orange, or may attain a weight of many pounds. There may be but one or two, or their numbers run into the thousands. In a typical case they are scattered over all the body, being thickest on the trunk, especially the anterior surface, and next on the scalp, face, and limbs. They are rare on the palms and soles, but have also been found on the mucous membrane of the lips and oral cavity. They are situated in the derma or hypoderm, perceptible only on palpation or projecting above the level of the skin as globular or ovoid growths, sessile or pedunculated, the majority tending to be somewhat constricted at their base. They are usually soft and elastic, freely movable, and painless. The integument covering them may be normal, pigmented, smooth, wrinkled, or stretched, and coarse hairs and comedones may be present. Some of the smaller tumors not infrequently atrophy and disappear spontaneously, leaving atrophic areas in the skin. While not invariably present, the syndrome is often completed by pigment spots distributed here and there between the tumors; and nævi, telangiectases, and other cutaneous anomalies are not uncommon. The neuromata or pseudo-neuromata may be felt along the course of a nerve as single fusiform or multiple bead-like swellings, which may give rise to secondary sensory and motor disturbances. Coexisting with the multiple nodules, or independent of them as the result of absorption or elephantiasic degeneration, there may be a pendulous tumor (*fibroma pendulum*) of enormous dimensions hanging down from its place of attachment in great folds and rolls and causing marked deformity of the part (Fig. 496). A lengthy nomenclature is attached to the condition, as elephantiasis mollis (Virchow and von Recklinghausen), pachydermatocele (Mott), plexiform neuroma (Verneuil), Rankenneurom (v. Bruns), dermatolyse (Marie), elephantiasis nervorum (Cushing and Helmholtz), etc. The temple and upper lid appear to be favorite sites (v. Bruns[17]), next the side of the head, the back, the buttocks, although no portion of the body is exempt. In the literature on the subject may be found a number of cases in which the affected tissue of the scalp sagged to the extent of distorting the face considerably by a large, sac-like growth or overlapping folds carrying the eyelid, ear, and lips with them. The eye is frequently destroyed by a secondary suppurative process. The mass may be picked up between the fingers and the parts restored to their natural outlines. When situated on other portions of the body, the same elephantiasic hypertrophy is produced.

Pathology.—The early growths consist of a loose edematous connective tissue which is very cellular, while the older ones are more fibrous and the cells in them less numerous. Large vessels are situated at their base, and many of the tumors are distinctly encapsulated. Von Recklinghausen[18] believed that they are primarily neurofibromata taking their origin from the nerve-sheaths, subsequently the sheaths of the other cutaneous structures participating. Nerve-fibers have been demonstrated in many of these growths, and in their absence he advances the hypothesis that they have disappeared or sacrificed their myelin, making them indistinguishable from the connective-tissue bundles. The obstruction of the superficial lymphatics in fibroma pendulum Crocker believes establishes a pathologic relationship to elephantiasis. At autopsy, in addition to the cutaneous manifestations, miliary fibromata have been found in the stomach and intestinal wall. Adrian[19] also found them in the mesentery and periosteum of the tibia, and he considers the presumption of an anomaly of the nervous system justifiable. Chauffard[20] and Marie found a degeneration of the pancreas and suprarenals, with hen's-egg-sized growths in the capsule of the latter.

Fig. 496.—Fibroma Pendulum.
In a patient with molluscum fibrosum and pigment spots.

Prognosis.—As a rule, the tumors do not affect the general health and are merely a deformity or an inconvenience from their size and location. The tendency is for them to enlarge slowly. From friction or injury ulceration or gangrene may take place, or they may become strangulated at their base and slough off. The neuromata may demand removal on account of sensory disturbance. The elephantiasic tumor, unless removed in its entirety, is apt to recur. Occasionally sarcomatous degeneration takes place.

Diagnosis.—When all the features of the disease are present, there can be no mistake, but in the absence of one or more it may possibly be confounded with multiple lipomata. The latter, however, are usually lobulated and never pedunculated. In molluscum contagiosum the lesions are superficially situated and have a central umbilication from which the bodies can be expressed. Sebaceous cysts frequently have a central opening through which the secretion can be pressed.

The **treatment** is surgical. In the large tumors care must be observed, as there is apt to be a great deal of hemorrhage. Two or three operations are often necessary, and extirpation must be complete to prevent a recurrence. The smaller ones may be destroyed by the galvanocautery or electrolysis or excised.

Carcinoma.—There are many classifications of carcinoma of the skin, the nomenclature being based on the macroscopic or microscopic appearance or both, relative malignancy, or genesis; but the following division suffices for all practical purposes: superficial, deep-seated or infiltrating, and secondary carcinomatosis.

Superficial Epithelioma.—Rodent ulcer may be taken as the type, as it is one of the most frequent forms met with. It begins as a small, hard, gray, pearly nodule, generally on the upper two-thirds of the face in individuals of middle age. Such lesions may be multiple, may remain for years with little or no change, or may disappear spontaneously. If removed before ulceration, there is only a slight tendency to recurrence. The growth slowly increases in size, and as a result of some irritation it breaks down in the center and appears as a superficial ulcer crusted with blood and secretions and surrounded by a hard, waxy, rolled margin (Figs. 497 and 498). In one form the central ulceration may heal, but is apt to recur, each time becoming somewhat larger, but seldom involving the deeper tissues; its base is red and granular, with scanty secretion, and rarely painful. In another, while healing in the center, it spreads at the periphery, or, again, one side may cicatrize, resulting in serpiginous ulcers with possible new foci in the scar tissue. Its course is very slow, but it may eventually destroy the greater part of the face and penetrate the skull, causing death from hemorrhage, exhaustion, or the involvement of vital organs. Although such cases have been reported, it seldom invades the lymph nodes, metastasizes, or gives rise to cachexia.

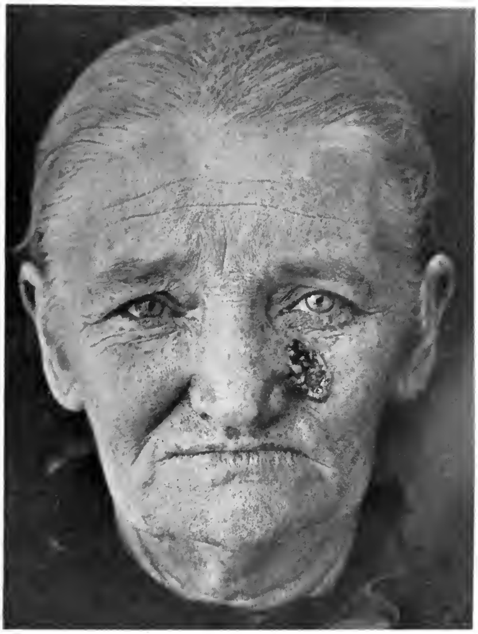

Fig. 497.—Epithelioma of the Face. Early stage of rodent ulcer, showing elevated pearly margin.

Microscopically, this tumor is made up of compact masses of cells which pass into the cutis in a branching manner. They are of the basal layer type, derived from either the epidermis or the outer layers of the hair-sheath.

The superficial papillary form is a growth of epithelium with consecutive hypertrophy of papillæ beneath. The seats of predilection of the primary are the genitals and lips. Secondarily they frequently spring from the base and periphery of carcinomatous ulcers, especially of mucous membranes and sometimes of the scalp. They often begin on a mole, wart, or other simple papilloma, attaining a large, cauliflower-like growth. As long as the epithelial proliferation is outward, the growths are easily removed, but when deeper tissues are invaded, they spread with alarming rapidity. Sooner or later ulceration takes place and the characteristic features of the affection are lost.

Fig. 498.—Rodent Ulcer. Advanced Stage.

Multiple epitheliomata are met with about the face, sometimes the hands and trunk, where there has been an antecedent condition known as senile keratosis. The skin is at first rough and covered with scales adherent to the follicular openings. Later scabby concretions of a dirty yellowish-brown form, underneath which is a warty condition which bleeds readily. Subsequently open epitheliomatous ulcers with hard, elevated edges and bases are formed. Years may elapse before malignancy develops, and the same patient is frequently affected with ulcers and papillomatous areas in different stages of growth.

Other senile changes in the skin, as pigment deposits, papillomata, alterations in the blood-vessels, and atrophy of the subcutaneous connective tissue predispose to malignant new-growths. These changes are allied to those which occur in xeroderma pigmentosum and in the condition known as sailor's skin. Multiple epitheliomata at times develop on old patches of psoriasis. The prolonged use of arsenic in this and other chronic skin diseases is followed by keratosis of the palms and soles or other localities, which terminates in tumor formation. They are met with in tar and paraffin workers on the scrotum and forearms, on the scrotum of chimney-sweeps, and on the hands and face of x-ray operators.

Tumors derived from the cutaneous appendages are quite uncommon.

There is nothing in their clinical features suggestive of their origin; they are benign in their course and the diagnosis must be made by the microscope. The belief is gaining ground that many of the tumors described as endotheliomata and cylindromata are, in reality, epitheliomata developed from congenitally misplaced basal cells.

Deep-seated Epithelioma (Fig. 499).—These neoplasms have their origin in the Malpighian layer and may occur anywhere on the skin, the mucous membranes, and the mucocutaneous junctions. Those of the lip and tongue are of this type, which is characterized by early ulceration, lymph-node metastasis, and tendency to recurrence. The lower lip near the median line is the usual location; the upper lip is rarely affected, but it has been noted in a few instances with primary growth of the lower. Epithelioma of the upper lip is, as a rule, some distance from the vermilion border and of the rodent ulcer variety.

Fig. 499.—Carcinoma of the Leg following a Sprain occurring Nine Months Previously.

The secondary lesion below the larger one began about six months after the original one. Enlarged inguinal lymph-nodes showed no cancerous involvement. Biopsy of both lesions showed squamous-celled carcinoma of a malignant type. Amputation of the leg was done.

The primary changes are often a hyperkeratosis over a limited area, followed by a fissure and then an ulcer, irregular in outline, surrounded by thickened and elevated margins. The base becomes indurated and the infiltration extends deeper; or there may be a primary erosion followed by warty granulations, or a hard nodule which later ulcerates. In neglected cases ulceration involves the entire lower lip and floor of the mouth with regional metastases. The average duration of life in untreated cases is three to five years, death taking place from sepsis or metastasis. It forms about 50 per cent. of surface carcinomata, and occurs most frequently in men, the large majority of whom are smokers. A few cases have been met with in women, most of whom were also addicted to the use of tobacco.

Histologically, the cells are derived from the prickle layers of the epidermis, grow deep into the corium and underlying tissue, and here and there undergo cornification, giving rise to horny pearls (Fig. 500).

Carcinomatosis of the skin is, in the majority of cases, secondary to mammary carcinoma or post-operative in the cicatrix. Small white or pinkish papules from the size of small shot to a pea appear and at times become confluent, resulting in infiltrated patches which may or may not undergo ulceration. The entire cutaneous surface over the front and back of the chest may be involved, sometimes extending to the abdomen and arms. The late stage, when the skin is hard and leathery, is known as *cancer en cuirasse*.

Etiology.—In a general way the statement is true that chronic irritation of slight intensity is one of the most potent factors which precede the malignant change in epithelial growths. Inflammatory changes in the papillary region of the derma, as in lupus, syphilis, ulcers, etc., by impairing the integrity of the basement membrane, favor the

FIG. 500.—EPITHELIOMA OF LEG FOLLOWING AN INJURY.
Spencer $\frac{1}{2}$ inch, Zeiss comp. oc. 4. Epithelial downgrowth with horny pearls.

downgrowth of epithelium. Atrophic changes in the connective tissue in advanced life exercise a similar influence, and scars from burns or other injuries, warts, and moles, especially if pigmented, are often a starting-point. Light probably plays an important rôle in their production. Hypersensitiveness to the actinic rays resulting in the production of hyperemia, pigmentation, telangiectasis, atrophy, hyperkeratosis, and finally cancerosis, is met with in early life in cases of xeroderma pigmentosum.

Diagnosis.—Superficial epithelioma must be differentiated from syphilis or lupus ulcerations by its course and characteristic elevated pearly border, which is present during the early years of growth.

In the later stages this characteristic edge is frequently lost, and we are then guided in making our diagnosis by the long duration of the affection, the absence of features pointing to syphilitic or tuberculous ulceration of the skin, or eventually by microscopic examination of excised tissue. Carcinoma is to be distinguished from extra-genital chancre and from gumma. In the former, the age of the patient, duration, early implication of lymph nodes, the type of ulcer, its superficial loss of tissue and protuberance, especially if on the lip, its indurated base, and a concomitant skin eruption are points which will assist in reaching a conclusion. Gummata are often multiple, deep-seated, rapidly ulcerate, with several openings, and lack the hard base. Not infrequently epithelioma of the tongue develops on a syphilitic lesion, and it is then difficult to determine the diagnosis without therapeutic or microscopic test.

Prognosis.—This is more favorable in the superficial and if the growth is removed in the early stage. Rodent ulcer in its later stages almost invariably returns. Superficial growths may become deep-seated and pursue a rapidly fatal course. Tumors from moles are decidedly malignant, and papillary ones attain a large size in a short time. The prognosis of the squamous-celled type is always more unfavorable, especially when the mucous membranes are implicated or secondary growths in the lymph nodes or elsewhere are present.

Treatment.—Circumscribed non-infiltrating epitheliomata are readily cured by excision, caustics, or curettage followed by caustics, the galvanocautery, or thermocautery. Curettage alone without caustics, like arsenic or zinc chlorid, spreads the growth by opening the lymph-vessels and favors its dissemination. Caustics destroy the cell growth beyond the reach of the curette, and if used when the slightest recurrence shows itself, many infiltrating epitheliomata may be radically cured with less destruction of tissue than by purely surgical methods. A certain percentage of rodent ulcers are cured by *x*-ray. Relapses are apt to take place, in which case treatment should be renewed. Where the growth is at all pronounced, removal may be expedited by first employing curettage and then *x*-ray. This treatment is indicated especially when it is situated at the inner canthus of the eye and involves the lid and nose, where operative interference would result in a good deal of deformity. The best effects follow after a decided reaction is produced by the rays.

Carcinomata of the lip and tongue should be treated surgically.

Cutaneous sarcoma may originate as a single primary pigmented or non-pigmented tumor or secondarily as a metastasis. There is a group called "sarcoid," which includes idiopathic multiple hemorrhagic sarcoma and sarcomatosis cutis.

Melanotic sarcoma or **melanoma** (Fig. 501) develops primarily or secondarily; if the former, it is single. Although the majority of such tumors are of epithelial origin and consequently pigmented carcinomata, a sarcoma may have its point of departure in a pigmented nævus or any pigmented spot; its favorite location being the dorsum of the hands and feet, lower extremities, genital region, and the face over the cheek or near the orbit, where it may have started from the choroid. In a few cases metastatic sarcomatous deposits on the face have been preceded by a diffuse bluish pigmentation. At the border of the nail a discoloration with a subsequent fungating pigmented tumor has received the name of "melanotic whitlow" by Hutchinson.

The initial tumor is small, generally flat, sessile, or pedunculated, smooth or lobulated, brown or bluish black, of hard or soft consistence. It may remain stationary, or ulcerate in the center, discharging a brownish black fluid, or, exceptionally, undergo spontaneous involution. As a rule, within a few weeks or months secondary pigmentary deposits appear which eventually become nodular. Generalization takes place through the veins with secondary visceral tumors, and death occurs in a few months or one or two years. In the last stages a general melanosis is at times met with, characterized by a brownish black discoloration of the skin, especially of the exposed parts. Pigment-granules have also been found in the blood and urine.

Non-pigmented Sarcoma.—The number of these tumors may run into

Fig. 501.—Melanosarcoma of the Thumb.

Began as a small, slightly pigmented spot in the matrix of the nail and in six months involved the thumb to the extent shown in the illustration. It was very vascular and deep black in some areas. Histologically the growth proved to be a giant-celled sarcoma containing pigment (courtesy of Dr. Wm. B. Trimble).

the hundreds. A primary single sarcoma may follow an injury, a vascular or other nævus, occur at the site of an old skin lesion, cicatrix, or develop on or beneath previously healthy skin. The growth may ulcerate and become the seat of a fungoid vegetation. Generalization takes place either spontaneously, after surgical interference or other irritation, the secondary tumors being found in the skin, subcutaneous tissue, viscera and glands.

When multiple, the lesions are pea-sized or larger, smooth or irregular, cutaneous or subcutaneous. At first the skin between them is not affected, but later it becomes swollen and painful and may attain elephantiasic proportions, ulcerating at one or more points and exuding an offensive secretion.

Idiopathic Multiple Hemorrhagic Sarcoma.—In this type pigmentation is due to cutaneous hemorrhages. The affection usually develops simultaneously on the extremities as circumscribed plaques or tumors. Occasionally it may appear first on the face or other parts of the body, or as a diffuse infiltration in or beneath the skin of a dark-red or purplish color, the early tumors being pea-sized or smaller and the infiltration as large as a dime or silver dollar. The legs, forearms, thighs, and arms are usually affected before the trunk or face is involved. The distribution is more or less symmetric, but sometimes grouped or confluent. The tumors are slightly painful, firm, and elastic; the older ones, especially on the lower extremity, are dark and do not change color by pressure; some have the appearance of angeiomata. A central depression in older growths and dark pigment spots mark the situation of others which have disappeared by spontaneous involution. Late in their course the tumors may ulcerate. The hands and feet may be much swollen and elephantiasic, but the general health is little affected except for the itching, burning, or pain. The mucous membranes and viscera may, however, be involved, the patient dying from exhaustion.

Sarcomatosis cutis, described by Kaposi, and *generalized sarcoma* resembling mycosis fungoides are two other types of growth which occur in the skin, and in leukemia and pseudo-leukemia generalized cutaneous and subcutaneous tumors are also met with which are closely related to the sarcoma growth.

Etiology.—The etiology is unknown. They may appear at any age, although they are perhaps more frequent in the young and after middle life. Traumatism or irritation has undoubtedly some influence on the development of these tumors. Symmetric growths appearing on the extremities independently may possibly have some toxic agent as an etiologic factor.

The embryologic status of tumors derived from moles is as yet not definitely fixed. It is strongly contended by Unna and others that they are carcinomata instead of sarcomata; on the other hand, the older view of their endothelial origin has again found favor. My own view is that in all probability both the epiblastic and the mesoblastic tissues are at times involved, thus giving rise to the confusion on the point of genesis.

Histologically, sarcoma is a connective-tissue growth made up of round or spindle cells. There may be mixed types, as fibro-, angeio-, or lympho-sarcoma. In the idiopathic multiple hemorrhagic there are many new formed blood-vessels and sinuses and blood-pigment.

Prognosis.—Some types, especially the single, are more apt to recur. The prognosis is always grave when metastases are present, death taking place in a few months or years. The melanoma is the most rapidly fatal, and the multiple hemorrhagic is the slowest in its course, cases of twenty-five years' duration being on record.

Diagnosis.—A pigmented growth developing in connection with a mole should excite the suspicion of a melanoma; whether sarcoma or carcinoma, it is equally malignant and can be differentiated only by microscopic examination. Syphilis, mycosis fungoides, and leprosy are diseases to be considered when the lesions are multiple. The syphilid, with which they might be confounded, differs in its more rapid evolution, its greater tendency to ulcerate, its color, and the presence of old scars. Mycosis fungoides is differentiated by its primary eczematoid and pruritic stage, the marked disposition of the tumors to undergo softening and ulceration, and their bright-red color. Leprosy is sometimes mistaken for the multiple hemorrhagic variety. The patches of anesthesia, the bullous eruption, and the characteristic facies of leprosy, as well as a microscopic examination of a nodule, will be sufficient to establish the diagnosis.

Treatment is not satisfactory, and operation is apt to be followed by a recurrence. It is the method of choice in primary single sarcoma. In Keen's[11] opinion all warts and moles should be excised as early as possible to anticipate the possibility of malignant changes which may take place in them. Arsenic administered hypodermically over long periods has cured multiple hemorrhagic sarcoma and multiple non-pigmented sarcoma. In a recent publication Coley[21] makes another strong plea for the use of mixed toxins of erysipelas and bacillus prodigiosus, not only in inoperable cases, but after primary operation as a prophylactic against a recurrence. The fungating growths in mycosis fungoides and the cutaneous tumors which develop during leukemia and pseudo-leukemia disappear after Röntgen-ray therapy, which retards in a remarkable manner the progress of these types of the disease. Recurrences are, however, frequent. The local treatment of ulcerating sarcomatous growths is conducted on general surgical principles.

Paget's disease is not confined to the nipple, and the literature would indicate that almost any part of the body may be attacked by an analogous condition. Next to the breast, it would appear that the affection occurs most frequently about the male genitals,[22] but the vulva,[23] umbilicus,[24] lips, nose, axilla,[25] pubic, perineo-anal, and gluteal regions[26] have all been sites for this disease.

It is met with in people past middle life, in whom nothing definite pertaining to etiology can be ascertained. Clinically, the malady runs a chronic course, often from ten to fifteen years, and it is not infrequently diagnosed as eczema. Wherever its localization, it has the same appearance—"a florid, intensely red, raw surface, very finely granular, as if nearly the whole thickness of the epidermis were removed."

The pathology consists of an acanthosis with elongated interpapillary projections. The cells are swollen and vacuolated. In the early lesion there is an infiltration of lymphocytes, plasma, and mast cells, chiefly confined to the papillary layer of the corium. In the tumor stage the cutis is invaded by the epithelial growth, and the epidermis is partly or entirely eroded.

Prognosis.—There is always danger of tumor development. In a case of my own the center of a patch in the gluteal region showed microscopically a typical rodent ulcer, and in the cases reported from the pubic and axillary region an epithelioma also supervened.

The **diagnosis** is to be made from eczema. In the early stages this is difficult, but later the sharply defined polycyclic margin which shows a slightly developed "rolled edge" enables one readily to distinguish it from that affection. It is questionable whether these cases of so-called Paget's disease in regions other than the breast should be sharply differentiated from superficial flat epithelioma, as some developmental phases, clinically or histologically, are not sufficiently dissimilar to justify placing in one category or the other.

Treatment.—This is essentially the same as that of epithelioma. The *x*-ray has given encouraging results in my own and other recorded cases.

Tuberculosis Cutis.—The skin is not a good medium for the growth of tubercle bacilli, and their presence is usually due to antecedent disease or injury, extension from contiguous parts, as the mucous membrane, bone, lymph nodes, testicle, etc., or exceptionally through the circulation. Multiple disseminated lesions in children after the acute exanthemata, especially measles, may be of embolic origin. Although not demonstrated in all the lesions ascribed to it, the organism has been found in lupus vulgaris, tuberculosis verrucosa cutis, scrofuloderma, and miliary tuberculosis.

French writers have given the name of tuberculide to certain papulonecrotic and ulcerative lesions which they believe are due to the toxins of the organisms, rather than to the direct action of the bacilli. Later investigations of Harttung and Alexander[29] and others would seem to indicate that certain of them are of embolic origin, the organisms themselves, living, dead, or attenuated, being carried from some extracutaneous focus to the deeper seated vessels of the skin, there giving rise to inflammatory changes and necrosis. The term comprehends lichen scrofulosorum, granuloma necroticum (folliclis), erythema induratum, and, according to some, lupus erythematosus.

As a rule, the types of tuberculosis of the skin are distinct and are expressions of the different ways in which the latter reacts to irritants at the site of infection. One form may pass into another, tuberculosis verrucosa changing to lupus vulgaris, or a lupus may develop from a scrofuloderma.

The clinical varieties of lupus vulgaris, tuberculosis cutis vera, tuberculosis verrucosa cutis (verruca necrogenica), and scrofuloderma are fully discussed by DaCosta (Vol. I, p. 639).

Erythema induratum (*Bazin's disease*) is characterized by more or less definite cutaneous or subcutaneous nodules localized upon the legs, especially the lower extremities of young people with the "strumous diathesis." The plaques, at first red, become violaceous, often ulcerate, and are painless and very chronic in their course (Fig. 502). In this form tuberculosis has been produced in guinea-pigs by inoculation. There is another type, dependent on vascular disease, which is followed by a necrotic phlebitis in middle-aged people. These lesions may closely resemble ulcerating gummata.

Diagnosis.—Late syphilis and certain forms of epithelioma are not infrequently mistaken for lupus. The gummatous syphilid is more rapid in its development and lacks the "apple-jelly" nodule; it is firmer in consistence, does not tend to invade the scar tissue, and usually other concomitant marks of syphilis are present. The therapeutic test may have to be resorted to. Serpiginous epithelioma has an elevated, waxy-looking margin, and a microscopic examination will quickly remove all doubt. Lupus erythematosus has symmetric erythematous patches, sometimes scaly, terminating in central atrophy, but having no lupus-nodules. It is usually a disease of adult life. Blastomycosis and protozoön skin infections must also be excluded. This would often be difficult without the aid of the microscope and cultures, which will quickly determine the diagnosis. Likewise the unusual types of pyogenic infection can be distinguished only by bacteriologic research.

FIG. 502.—ERYTHEMA INDURATUM (BAZIN'S DISEASE). The illustration shows an active lesion on the left leg, with superficial ulceration at the margin of the patch. On the right leg numerous scars are present from older lesions which have healed spontaneously. The patient was a girl, sixteen years old, who presented no stigmata of hereditary syphilis.

Treatment.—The Finsen light therapy of small lupous lesions gives the best cosmetic results. Recent untreated cases respond most rapidly, a few treatments healing with little scarring a limited patch which had not been previously touched, but months or years may be required to cure an extensive involvement of the skin which is the seat of scar tissue and relapsing nodules after the curette and caustic. At the Finsen Institute the average daily séances are one hour and ten minutes, a different spot being chosen each day until the reaction from the preceding one has passed away. This may require about two weeks. The pigmentation following may last several months, but eventually disappears. The success there is due in a large measure to the intensity of the light obtained from their lamps, and their extensive experience in treating such cases. In ulcerating lupus the x-rays are successful in healing the open sores, after which the Finsen rays may be employed for the underlying nodular infiltration. The Röntgen rays have also been successfully employed in non-ulcerating lupus. Excision of small patches may be practised when feasible; if not, thorough curettage, followed by the use of the Paquelin cautery. On the mucous surfaces the infiltration is treated by the galvanocautery or locally by the following formula:

℞. Iodin,	4	(ʒj)
Potass. iod.,	8	(ʒij)
Aq. dest.,	8	(ʒij)

Lupus of the palate may be painted daily or oftener with a mixture of equal parts of resorcin, balsam of Peru, and mucilage. Recurrences of the disease must be looked for and treated. The general treatment differs in nowise from that pursued in other forms of the malady.

Lupus erythematosus is a chronic inflammation of the skin of unknown etiology, leading to superficial atrophic scarring.

Women are more often affected than men, usually after the second decad of life. It is rare in the very young or the old, and its development seems to be favored by cold climates. The determining causes are obscure, although it is associated not infrequently with local or general tuberculosis or occurs in those with a tuberculous family history. Boeck[28] ascribed it to the toxin of tubercle bacilli producing a disturbance of the vasomotor centers of the skin followed by an inflammation of the corresponding part of the cutis. Clinical experience shows that areas the seat of a chronic hyperemia, or damaged by frost-bite or an antecedent condition, like seborrheic dermatitis, are more apt to be affected by the discoid form; and while our present knowledge points to the conclusion that the blood supply is primarily interfered with, the normal capillary pressure being raised, the question as to whether the toxemia responsible for the changes is a general or a local one or whether additional factors are concerned is still open to investigation.

The clinical varieties are the discoid, disseminated, telangiectatic, and nodular. The discoid is the most common, attacking the hands and face, especially the nose, cheeks, and lobes of the ears, often symmetrically. Usually it begins as discrete or grouped small red spots with firmly adherent yellowish scales, which on removal are found to have stalactitic processes dipping into the follicles, leaving the mouths of the latter distended. The lesions extend peripherally and coalesce, resulting in a patch slightly elevated above the surrounding surface, with a well-defined border and undergoing central involution with atrophic scarring (Fig. 503). In the course of years the nose and cheeks, the so-called "flush area," may be involved, the plaque resembling a butterfly in outline. The next most frequent locations are the orbits, lips, scalp, and backs of the fingers and toes. The mucous membrane of the mouth may also be implicated. As a rule, ulceration does not take place spontaneously, except in the lobes of the ears and on the scalp. There is no disturbance of the general health in this form, but, of course, complications may occur. Locally there is tenderness or itching or even severe pain, and enlarged regional lymph nodes are quite frequent.

The disseminate type may be acute from the beginning or may supervene upon a localized chronic condition. It is more apt to be erythematous than seborrheic, appearing on the face first and spreading to the limbs before attacking the trunk, and instead of scales, crusts adhere to the sebaceous mouths. Occasionally there are acute and subacute cases, with constitutional symptoms, as fever, severe headache, pains in the bones and joints, and albuminuria.

In the telangiectatic form there may be noticeable only a persistent circumscribed erythema on the cheeks, but the tissues are found to be infiltrated when picked up between the fingers.

Pathology.—The main changes are found in the corium, consisting of an edema with degenerative changes in the connective tissue and the appendages, a cellular infiltration, greatest about the vessels which are dilated, and a capillary thrombosis. Epidermic changes are variable, but usually a hyper- or para-keratosis is encountered, the horny layer dipping into the orifices of the follicles, with a thinning of the rete.

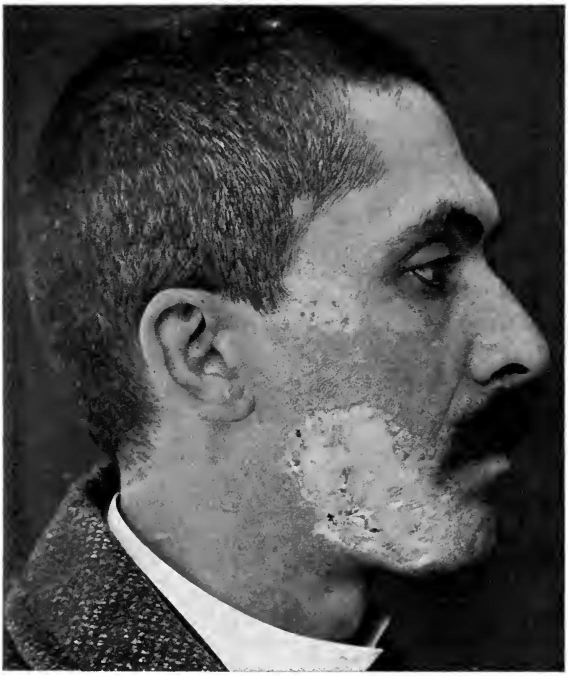

FIG. 503.—LUPUS ERYTHEMATOSUS (DISCOID VARIETY).
Several sharply circumscribed lesions over the face and in the scalp, not showing the usual butterfly appearance of the affection.

The **course** is a very chronic one, covering a long period of years. Some cases get well spontaneously or as a result of treatment; in others, intervals of inactivity are succeeded by a new outbreak, or while old foci are disappearing new lesions develop. Pulmonary tuberculosis is not an unusual termination in this affection. The acute form is serious and should have a guarded prognosis.

Blastomycosis is a chronic papillary dermatitis due to a yeast fungus. The relationship between the infection and its development is still undetermined. Some cases give a history of preceding trauma, and men are probably more frequently exposed. The most accessible parts, as the hands, face, and skin about the orbit, seem to be favorite sites, but other regions, as the sole of foot, leg, thigh, etc., may be attacked.

Clinically, the disease begins as a papule or papulo-pustule, soon becoming covered with a crust, which on removal discloses a papillomatous area. It enlarges by peripheral extension or by the coalescence of adjacent foci. In the course of weeks or months other parts of the body may be affected by auto-inoculation. A typical patch is elevated, verrucous, or fungating, with a soft base which is infiltrated with a seropurulent secretion (Fig. 504). The border is dark red or purplish and slopes more or less abruptly to the normal skin, from which it is sharply defined. It is studded with minute, mostly microscopic, abscesses, which are also seen in other parts of the growth and not infrequently in the thick, scar-like tissue which has superseded the active lesions. On pressure they exude a small amount of mucopus. While the malady remains confined to the skin, the general health is not much impaired, but several cases of systemic infection[30] are on record. In two the lungs were primarily involved, the course simulating tuberculosis; in the others the initial infection was apparently cutaneous.

Fig. 504.—Cutaneous Blastomycosis.
An extensive lesion of the forearm showing a verrucose condition of the surface with central scar formation (courtesy of Dr. Hyde and Dr. Montgomery).

Histologically the rete is the seat of extensive hyperplasia and contains miliary abscesses with contents composed of leukocytes, detritus, the organisms, and giant-cells. The corium shows subacute, chronic, and occasionally acute inflammatory changes with abscess formation. The infiltration consists of leukocytes, young connective-tissue cells, plasma, mast and giant cells, and there is also hyperplasia of the vessels. The blastomycetes are double contoured, highly refractive bodies measuring 7 to 20 μ. They occur in pairs, singly, and in groups, and often as budding forms. They are found in the miliary abscesses and frequently in the giant cells, and can be demonstrated in the fresh state by placing tissue or pus between a slide and cover-glass with a drop of water and 10 to 30 per cent. solution of caustic potash or equal parts of caustic potash and glycerin.

The **diagnosis** must not be confounded with papillary and superficial forms of carcinoma, lupus vulgaris, or verrucous tuberculosis, vegetating syphilitic lesions, or a vegetating dermatitis due to pus-organisms complicating other dermatoses. The quickest and most positive method of differentiation is by means of microscopic and bacteriologic examination of tissues and smears and animal inoculations if tuberculosis is suspected.

Prognosis.—Ordinarily, if limited to the integument, the malady is not fatal, but the possibility of systemic infection should not be forgotten. It is often refractory to treatment, and may result in a great deal of disfigurement.

Treatment.—In all cases cleansing and antiseptic lotions are beneficial. Complete extirpation of lesions has been successful, but curetting does not always prevent their recurrence. The treatment most efficacious seems to be large doses of potassium or sodium iodid, 200 to 500 grains a day, with the *x*-ray as an adjuvant for the more obstinate areas.[31] More recently Bevan[32] advocated copper sulphate, with which he obtained good results, in dosage of $\frac{1}{4}$ grain t. i. d., increasing it to $\frac{1}{2}$ grain t. i. d., and externally a 1 per cent. copper sulphate wash.

Diseases of the Nails.—Affections of the nail are usually secondary to disease about it which often involves the matrix and leads to deformities and loss of the nail. Tuberculous inflammation (*onychia maligna*), as a rule, affects only one finger. In the beginning it is similar to eczema, but the latter attacks more than one finger. The tissues about the nail are thickened, fungating, and sometimes show lupous nodules on pressure. The treatment consists in destruction with the galvanocautery under anesthesia, radiotherapy, or phototherapy.

Chancre about the nail may be mistaken for panaris, eczema, or tuberculosis at the side or base of it. The usual features of initial lesions, as induration and surface erosion, are absent, and the diagnosis is made by exclusion—the absence of acute manifestations, long duration, involvement of the epitrochlear lymph node, and eventually the skin eruption.

Perionychia usually begins at the base or side of the nail as a blister containing serum, spreads around the nail, and suppurates.

Treatment.—If there is fluid beneath the nail, the latter should be split, or if loose, removed. Dilute tincture of iodin may be applied or a solution of 1 per cent. zinc sulphate and 0.5 per cent. copper sulphate in water.

Sclerodactylitis is an affection of the skin of trophoneurotic origin leading to a loss of the terminal phalanges, which is preceded by atrophic changes in the nails. In lepra and syringomyelia a chronic paronychia is present, and whitlow in its worst form is a symptom of Morvan's disease.

Ingrowing nail most frequently affects the external border of the great toe, less often the internal border, and rarely the other toes or fingers. In mild cases the cuticle simply encroaches on the nail, but from repeated irritation the skin of the nail-fold becomes inflamed, thickened, and overhanging, and some trifling injury will initiate bacterial infection with suppuration and exuberant granulations. Pain is usually intense, there is a foul discharge, and in severe cases cellulitis may develop. The condition may arise spontaneously or from pressure of short or tight shoes or stockings or contiguous toes, improper paring or traumatism in individuals especially predisposed.

Treatment.—Proper shoes and care of the nails are the first indications. The cuticle should be pushed back and a little cotton placed under the nail. In the chronic cases, as palliative measures, a triangular piece of the nail may be excised and the granulations destroyed with silver nitrate, a weak solution of formalin, the curette, or cautery. Or the nail may be elevated by cotton until the ulceration has healed and the nail grown out beyond the diseased tissue. Should these fail to give relief, the simplest operation (von Bergmann[33]) is to make a lateral curved incision below the ulcerated skin, extending about three-eighths of an inch back of the nail-fold. From the latter point a straight incision is made directly forward through the nail and the tissues excised, being careful not to leave any matrix or nail at the side or upper angle. The edge of the skin is then applied and held by the dressing against the edge of the nail. This procedure is done under local anesthesia and a small tourniquet around the toe above. If the course is favorable, the patient is usually about in a week.

In **onychauxis,** or **hypertrophy of the nail,** the growth is chiefly forward. It is apt to be twisted, sometimes spirally; the nail is thickened, strongly ridged, shining, yellowish or brownish. Underneath there is often a collection of macerated epithelium. It is generally limited to the toes, most frequently the great, but the nails of the fingers may also be affected. The tendency seems to be hereditary in some instances. **Onychogryposis** (unrestrained growth) is seen chiefly in bedridden and elderly people, or in those who neglect cutting their nails, in elephantiasis, and in inflammations.

Deformities of the Nails.—Congenital absence or atrophy is rare. Supernumerary nails may be present either on a supernumerary digit or two on one digit or they may be abnormally situated. They may be acquired on stumps of amputated fingers or where the terminal phalanx has been lost.

Transverse furrows result from defective or disturbed nutrition during illness.

Koilonychia or *spoon-nail* is thin and concave from side to side, with everted edges. It begins on one finger, gradually involving the others. It is observed in some wasting diseases, is sometimes congenital and inherited, or the soap lyes may produce it in washerwomen.

White nails are spots or bands produced by the presence of air between the lamellæ of the part affected; the origin may be traumatic or trophic.

Tylosis is a callosity of the matrix of a finger or toe. If the latter, walking or standing is very painful. The nail should be split or extracted to remove the callosity.

Reedy nails, with very marked, long striæ, and regarded as a sign of gout, are common in the old.

Brittleness or *onychorrhexis* may be congenital or acquired. It is associated with developmental anomalies or nervous troubles.

Separation of the nails takes place in inflammation of the finger-tips or without apparent cause.

Shedding of all or certain nails takes place in the neurotic, in syphilis, typhoid, universal alopecia areata, diabetes, hysteria, after section of the sciatic nerve, sometimes in the course of tabes, after acute inflammations of the hand, epidermolysis bullosa, and prolonged exposure to the x-ray.

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CHAPTER XXXI.

PATHOLOGY OF THE CHIEF SURGICAL DISORDERS OF THE NERVOUS SYSTEM AND ITS IMPORTANCE IN CLINICAL DIAGNOSIS.

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INTRACRANIAL HEMORRHAGE.

Spontaneous intracranial hemorrhage affords little opportunity for surgical intervention. It occurs as a result of diseased blood-vessels, either with or without rupture of the vessels,—more frequently with rupture,—and in some cases from the bursting of an aneurism. There seems to be no certainty in the diagnosis of cerebral aneurism from the symptoms; the latter are occasionally those of a focal lesion, especially if the aneurism is near the chiasm, and I have known sudden death to occur from rupture of an aneurism at this part. More frequently the aneurism is latent and is not suspected until it is found at the necropsy, or sudden death occurs in a person who had been in fair health, or whose symptoms had been of a diffuse character. Aneurism is not common in the brain, but when it does occur, it is more likely to implicate the basal vessels. The miliary aneurism of the intracerebral vessels is common and well known since the writings of Charcot and Bouchard, but it has seemed to me that too much has been attributed to it, and that intracerebral hemorrhage may occur from other causes than the bursting of a miliary aneurism. Von Monakow[1] says in regard to this that the most common and perhaps the only positive cause for spontaneous hemorrhage is rupture of a miliary aneurism, but he acknowledges that in some cases the miliary aneurism cannot be found. Dissecting aneurisms, in which the blood is in a sac-like enlargement of the adventitial spaces, occur, and may be associated with miliary aneurisms. Aneurisms in children have been attributed to congenital defects of the media or to infectious emboli carried from the valves of the heart in varicose endocarditis.

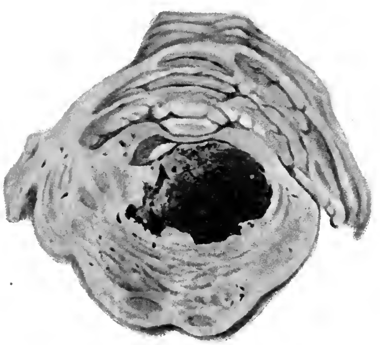
If there were definite means of determining the existence of a cerebral aneurism, operation would be in order and the affected vessel could be tied, but the boldest surgeon may well hesitate before such an undertaking when the symptoms point to a lesion at the chiasm or at the base of the brain. Since Horsley[2] has operated upon ten cases of tumor of the pituitary gland and reports that he has been able to expose the base of the brain so as to obtain a good view of it, operations for basal aneurisms assume more importance.

Hemorrhage in the brain is caused by disease of the blood-vessels, by weakening of the surrounding supporting tissue from softening, senile atrophy, inflammation, etc., and by increase of the blood-pressure, as in rapid cardiac action; the most important of these factors is the vascular disease.

In most cases the rupture of the blood-vessel occurs in or near the basal ganglia, and these structures may be completely destroyed or only slightly affected by the hemorrhage. The latter is not always of rapid development, but, in the form known as ingravescent, may take some little time to reach its height. Occasionally closure of a small vessel occurs by thrombosis or embolism, and the softening of the surrounding brain tissue weakens the resistance to other vessels and these in turn rupture. Hemorrhage in this way may require one to three weeks before it is complete, and is known as late apoplexy (Spätapoplexie). The spontaneous hemorrhage is usually in the distribution of Charcot's artery of cerebral hemorrhage (the lenticulo-striate), but frequently also in the lenticulo-optic, and rarely occurs in the cortex or white matter above the basal ganglia. Hemorrhage of the pons (Plate VIII), medulla oblongata, or cerebellum also is rare. The surgeon has little opportunity to operate in cases of spontaneous hemorrhage, because he seldom can hope to find rupture of one of the superficial vessels of the brain in an accessible position, and it is exceedingly doubtful whether the patient's chances for improvement are increased by opening the skull and puncturing the brain when the hemorrhage is in or near the basal ganglia.

Traumatic hemorrhage is a very different matter from the surgeon's standpoint. Here there are often clear indications of cerebral injury, and one may know from the external signs where to operate when the symptoms are not localizing. The blood collection is often epidural and associated with depressed fracture of the skull, or there may be a linear fracture without displacement. The middle meningeal is the artery most frequently affected, and the clot formed by rupture of this vessel may be extensive. Subdural hemorrhage has been more frequent in my experience than epidural, and I have repeatedly seen a hemorrhage beneath the cerebral dura as a result of injury to the head in cases where the skull was not fractured. This occurrence is important to remember, and sometimes the discovery of a subdural hemorrhage comes as a surprise to the operator. Too frequently these subdural hemorrhages without signs of fracture are overlooked, and the clot is allowed to remain without operation. In course of time it becomes organized and contracts, but acts as a source of irritation and may cause epilepsy, especially as it often is near the motor area, but may produce convulsions even when in other parts of the brain. The symptoms may indicate that the lesion is at a point remote from where the injury was received, and probably these remote symptoms are produced by *contre-coup,* and usually they soon disappear. The pathology in such cases is uncertain; but just as a vessel may be ruptured without fracture of the skull from force applied from without, so a blow received at one part of the skull

PLATE VIII.



HEMORRHAGE IN THE TEGMENTUM OF THE PONS, DIAGNOSED CLINICALLY.

may transmit a part of its force to the portion of the skull opposite the seat of impact and cause congestion, edema, and possibly small hemorrhages at this part of the brain, conditions which are not persistent, or at least do not cause permanent symptoms. The superior longitudinal sinus has been ruptured by trauma of the head without fracture of the skull. Usually a hematoma or ecchymosis of the scalp may be found to indicate where the blow was received, and the injury of the brain, in my experience, is likely to be most severe where these external signs are found. Where basal fracture has occurred, I have seen, however, the hemorrhage covering the greater part of both cerebral hemispheres and the base of the brain. The brain itself is often implicated in the hemorrhage, and removal of the blood upon it does not remove all the lesion. It is this complication that causes many of the severe and persisting symptoms of trauma capitis. A large hemorrhage may be found upon the brain at one part and numerous minute hemorrhages at other parts; the latter, by their multiplicity, cause wide-spread disturbance of cerebral function; along with this are degenerative changes occurring in the nerve-cells and nerve-fibers and intracerebral capillaries. It is not surprising, therefore, that the clinician sees so many cases of impairment of mentality following a severe blow upon the head. As a late result of these intracerebral hemorrhages numerous sclerotic areas may be found in the cortex where the nervous tissue at these regions has been destroyed. [NOTE.—In correcting this proof opportunity is taken to call attention to an important paper by Cushing on cerebral hemorrhage, "New York Med. Jour.," Jan. 19 and 26, and Feb. 2, 1907.]

Recently hemorrhage occurring in the new-born child has assumed greater importance in the mind of the surgeon. The pressure of the forceps, the overlapping of the parietal bones and tearing thereby of the superior longitudinal sinus, are among the means by which intracranial hemorrhage occurs in the new-born. It must not be forgotten that the brain also is often injured in these cases, that sometimes porencephalia is probably caused by cerebral hemorrhage, and that softening and absorption of the diseased brain tissue with the formation of porencephalia would occur as truly after the meningeal hemorrhage had been removed as when it had been left untouched. The brain of the new-born child is very poorly medullated and very soft; the results of pressure upon it, as by meningeal hemorrhage, therefore are more serious than they would be in the adult. It is the implication of the brain in these cases of hemorrhage of the new-born that is so much to be feared. Gowers[3] suggested, some years ago, the removal by operation of the meningeal hemorrhage caused at birth, but Cushing[4] seems to have been the first to perform the operation. His reports are encouraging, but it will be necessary to wait many years before we may be able to judge of the late results of this operation. It is not improbable that many children with very defective brains will have a miserable existence prolonged by an early removal of pressure. I have known epilepsy to develop ten years after a cerebral injury, and other similar cases are recorded; it is therefore too early to form any definite opinion regarding the benefit of this operation. Abnormal pressure upon the brain, however, should always be removed, and therefore the clot caused by injury at birth falls under this rule. In some cases the damage to the brain is doubtless slight where early operation is performed.

Hemorrhage may follow occlusion of the venous sinuses of the brain, and I have observed the ventricles of the brain of a child filled with blood following thrombosis of the straight sinus (Fig. 505). Hemorrhage also occurs in rare instances in the brain of children without trauma. The cause may be inherited diseased arteries, usually from syphilis, or it may be from some infection. In some cases no cause can be determined.

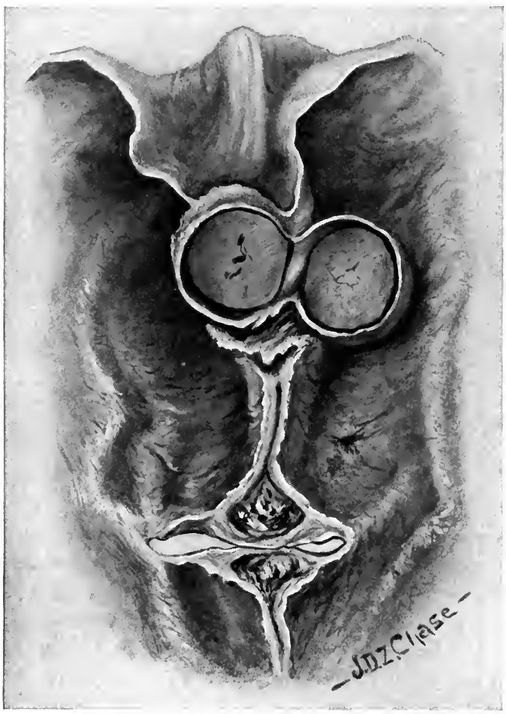


Fig. 505.—Thrombosis of the Straight Sinus; Calcification of the Superior Longitudinal Sinus (shown in the Lower Part of the Illustration).

Gradually, the color of the hemorrhage changes from a deep red to a brownish-red, the clot becomes partly absorbed and semifluid, and finally fluid. The tissue about the clot becomes denser and may form a wall, often stained with ochre-colored pigment, and the brain in the region of the lesion contracts so that the resulting cyst is much smaller than the original hemorrhage. The whole cerebral hemisphere may atrophy after a large hemorrhage, as the result of secondary degeneration in many fibers cut by the hemorrhage. When a large hemorrhage forms in the brain, usually numerous small hemorrhages are found in its neighborhood or at some little distance. These are probably produced by diapedesis in the adjoining vessels as a result of great blood-pressure. When hemorrhage ruptures into the ventricles, death is usually rapid, but hemorrhage may occur directly into the ventricles, as from a rupture of the choroid plexus, and a fatal termination may result within a few minutes (*apoplexie foudroyante*). At the necropsy the ventricles may be found filled with blood, and blood may cover the base of the skull. When hemorrhage occurs into the basal ganglia, the rupture into a lateral ventricle may follow after some hours. The hemorrhage in the basal ganglia is usually large, because the lenticulostriate and lenticulo-optic arteries are under great pressure, and when ruptured, much blood is poured out—often more than in hemorrhage from a cortical artery.

Hemorrhage in or beneath the cortex, non-traumatic in origin, is believed to be much less frequent than hemorrhage in the basal ganglia. In the former position the hemorrhage is usually smaller, is less likely to be fatal, the blood-pressure within the cortical arteries is less, and as a fatal termination is less frequent, cortical hemorrhage may occur oftener than is commonly supposed, and some of the cortical scars and cysts usually attributed to thrombosis may be from hemorrhage. Excellent presentations of the subject of cerebral hemorrhage may be found in the text-books by Oppenheim,[5] Mills,[6] and others.

INTRAVERTEBRAL HEMORRHAGE AND LESIONS OF THE SPINAL CORD IN FRACTURE OF THE VERTEBRÆ.

Trauma may cause hemorrhage upon the external surface of the spinal dura. This, in my experience, is rare, and is hardly to be considered in deciding for or against operation. It may occur as a result of tearing of the epidural vessels; by wounding of them by the penetration of a fragment of bone; it may be the leakage from injury of the vertebræ. Alone, it probably seldom produces grave symptoms, and where it is extensive, it is likely to be associated with severe injury of the cord itself. The same may be said of pial hemorrhage. Occasionally the wound becomes infected, but this is not likely to occur unless it extends to the external surface. Such a wound may be produced by a bullet or dagger. In the later stages adhesions may form between the dura and pia at the site of injury, and by compression of the blood-vessels, together with thickening of their walls and narrowing of their lumina, may impair the nutrition of the cord and lead to still greater destruction of the nervous tissue.

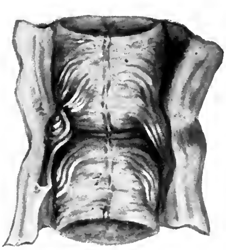


FIG. 506.—COMPRESSION OF THE SPINAL CORD FROM FRACTURE OF THE VERTEBRÆ.
The two ends of the cord are held together merely by pia.

Much caution should be observed in removing the spinal cord for examination in a case of fracture. It is sometimes difficult to determine the extent of the fracture, and the instruments employed at the necropsy may readily cause artefacts. Pressure or pulling on the softened cord may modify very greatly the condition caused by the trauma.

The changes produced in the soft spinal cord by injury, either with or without fracture of the vertebræ, are often very striking. The cord is sometimes almost completely severed, the two ends being held together merely by the pia (Fig. 506). Where the damage is less severe, the cord externally may appear to be unaffected, and not infrequently when exposed at operation may appear to the surgeon to have escaped, and yet the alteration may be so intense within as to destroy all function.

The white matter may be so intermingled with the gray that the normal

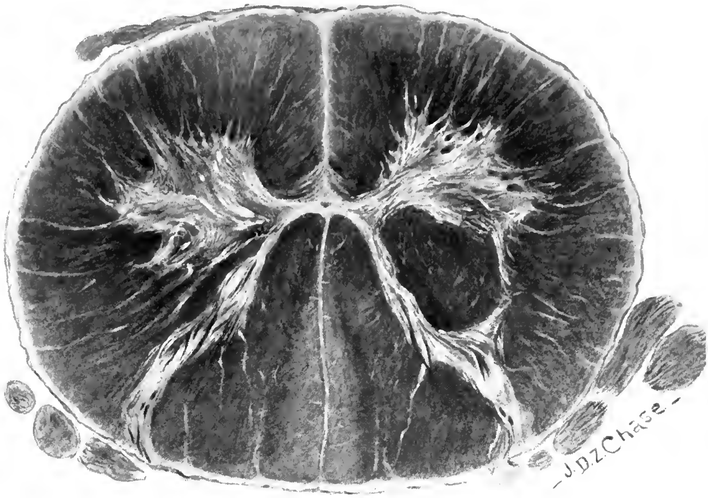


FIG. 507.—FRACTURE OF THE VERTEBRÆ.
The cord externally appeared unaltered, but on section the white matter was found displaced within each posterior horn, as a result of the trauma.

configuration of the cord in transverse section disappears entirely (Figs.

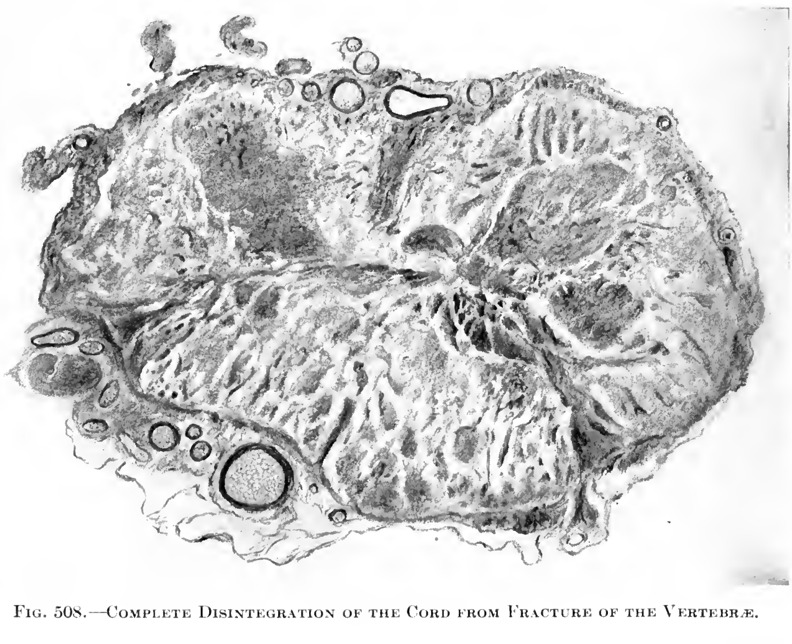


FIG. 508.—COMPLETE DISINTEGRATION OF THE CORD FROM FRACTURE OF THE VERTEBRÆ.

507 and 508). The nerve-fibers of the white matter may be driven as a

wedge into the gray, and in a transverse section may run in a longitudinal direction and be inclosed by a ring of gray tissue. The nerve-cells in the greatly affected regions are much altered and appear in various stages of degeneration, or may even entirely disappear. The blood-vessels of the cord at the site of injury become thickened, and later the neuroglia proliferates and causes dense tissue here, very unlike the normal cord structure. Minute hemorrhages within the cord substance occur in most cases of severe trauma, and sometimes the quantity of blood poured out within the tissues may be considerable, forming a large hematomyelia, even without fracture of the vertebræ. The medullary substance and axis-cylinders swell, and many of the nerve-fibers entirely disappear, leaving holes within the tissues causing a lace-like structure. Numerous small mononuclear cells may be found about the blood-vessels and within the spinal cord, as well as collections of fatty granular cells containing the débris of degenerated nervous tissue. Such changes interfere with or entirely prevent the transmission of impulses through the affected area, and, as has been said, may occur without any external alteration of the cord. It is, therefore, impossible at operation in cases of vertebral injury to determine the full extent of the damage to the spinal cord.

Secondary degeneration, in the crossed and direct pyramidal tracts below the lesion, and in the tracts of Gowers, the direct cerebellar tracts, and the posterior columns above the lesion, occurs as a result of the injury, but probably causes no symptoms, as it is merely a result of destroyed nerve tissue at one part of the spinal cord.

Serious injury of the spinal cord in the conus medullaris is sometimes produced by lumbar puncture. On one occasion I had the opportunity of observing a young child on whom lumbar puncture had been performed a little too high and paralysis of the lower limbs occurred. The spinal cord in the adult does not extend below the second lumbar vertebra; in the child it may extend a little lower. If the puncture is made between the second and third lumbar vertebræ, the needle may penetrate the spinal cord and cause hemorrhage within it, or within the cauda equina, with resulting paralysis.

The chief, but not the only, cause of hematomyelia is trauma; indeed, Minor[7] says that of the many cases of hemorrhage within the cord he has observed, in two only the bleeding seemed to be spontaneous; all the others could probably be attributed to trauma. The hemorrhage often extends a long distance from the seat of injury, and is especially in the gray matter; it may in rare cases extend almost throughout the entire length of the cord, chiefly within the gray matter. The gray matter is looser in structure than the white, and is more vascular, and, having its nerve-fibers running in various directions, does not afford the same resistance as do the parallel and longitudinal bands of fibers within the white matter. When hemorrhage occurs into the cord, it therefore is soaked up by the gray matter, and may extend as far above the lesion as below, or even further. The position of dorsal decubitus, necessitated by the paralysis, may favor the upward extension of the hemorrhage.

Most hemorrhages are in the posterior horns rather than in the anterior, and not infrequently break into the adjoining white matter of the lateral, and especially of the posterior, columns. The cervical and upper thoracic regions are most often implicated by the hematomyelia, as these portions are most frequently the seat of trauma.

The changes that occur in the spinal cord as a result of trauma are of much importance to the surgeon. Injuries of the vertebral column are, unfortunately, very frequent, and the question as regards operation is difficult to decide. Some believe that operation should be performed in every case of fracture of the vertebræ, supporting their position by the statement that no harm can be done by operation, and that much benefit may result therefrom. Others assume a very skeptical attitude and doubt whether operation is of much advantage, and whether the chances would not be greater for the patient without it. A study of spinal cords removed in cases of fracture, it seems to me, should increase the adherents to the latter view for the majority of cases. Improvement occurs in certain cases without operation, and in others no benefit can be detected as a result of operation; these facts may be brought forward by those opposed to surgical intervention in support of their opinion. The surgeon, on the other hand, may refer to some cases in which benefit has followed intervention, and to the many cases in which no operation has been performed and no improvement has occurred, in assuming that had he been given an opportunity to interfere, the results might have been different; and on his side he has the urging of the relatives, and often of the patient also, who clamors for some active treatment. There are cases that improve with or without surgical intervention, and others that cannot be benefited in any way. It is only by a study of the spinal cord in many cases of vertebral injury that we are able to draw proper conclusions. The plea, however, that no harm can be done by operation, and the advice that it should, therefore, be performed in every case, are founded, I think, on erroneous premises, and are capable of working much mischief. I have known paralysis of the bladder and rectum and loss of sensation to follow operation performed about one year after the injury of the vertebræ had occurred, and this case shows, in a way that an early operation would not, that operation may cause great damage. These unfortunate results may be by edema, congestion, inflammation of the spinal cord, or shock, and in some cases by infection of the wound. The operation, in my opinion, is to be avoided unless it can be distinctly shown that the chances of improvement are increased by it, but often the surgeon will be compelled to operate.

It seems to be held by many that the symptoms of compression of the cord are caused by pressure of broken pieces of vertebræ, and that these should be removed in order that regeneration of the cord may occur. Unfortunately, the trauma which has been severe enough to cause fracture or dislocation of the vertebræ, produces, at the same time, compression or destruction of the cord (Fig. 509) or hematomyelia. The spinal cord is not elastic, and when the displaced fragments of bone have been removed, the cord does not expand to its former dimensions.

The subject of operation will be discussed in another chapter of this work, but it has seemed advisable to say a few words here regarding it from the pathologic aspect. Haynes[8] has recently presented the objects supposed to be accomplished by laminectomy: (1) To remove the bullet or spicules of bone or particles of clothing; (2) to remove blood-clots; (3) to arrest hemorrhage; (4) to allow for oozing in traumatic edema of the cord; (5) to prevent pressure and sepsis by free drainage; (6) to arrest advancing paralysis ; (7) to suture the cord.

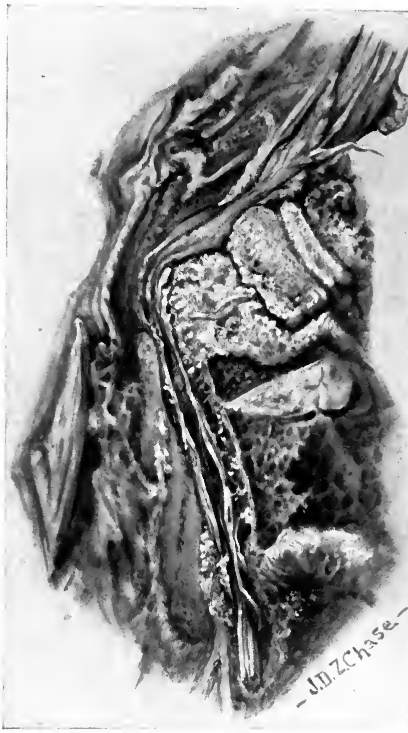


Fig. 509.—Complete Crush of the Lower Part of the Spinal Cord from Fracture of the Vertebræ.

Roots of the cauda equina are seen at the lower part of the illustration.

It seems to be the opinion of some that the symptoms of compression of the cord are caused by secondary degeneration of the nerve-fibers of the cord. Secondary degeneration is an effect, not a cause. The symptoms begin from the instant the compression occurs, and the only effect secondary degeneration could possibly have would be to prevent recovery. It would occur if the fibers were severely injured, whether the compression were immediately removed or not. The bullet in gunshot wounds is occasionally in the canal, but usually lies in the body of a vertebra or in some inaccessible part. Where blood-clots are found on the cord, hemorrhage will often be present within the cord also, and removal of the external clots accomplishes little. The arrest of hemorrhage after the initial shock has passed I shall leave for the surgeon to discuss; it does not seem to me an imperative cause for operation. Oozing in traumatic edema of the cord deserves consideration. Unquestionably, edema occurs, as shown especially by Krause[9] recently, but it probably is not usually removed by operation.

Serous spinal meningitis is decidedly a new subject and of much interest to surgeons. Cerebral serous meningitis has been recognized for years, and the association of it with the spinal form is not remarkable, but it is worthy of note that serous meningitis may be confined to a small portion of the spinal cord. I know of but one case that demonstrates the truth of this statement—the case recently reported by Fedor Krause.[9] In this a portion of the cervical spinal dura was much distended by fluid, so that when the posterior portions of the vertebræ were removed at operation, the dura assumed a spindle-shape within the opening. That the symptoms of compression of the cord were due to this collection of fluid was shown by their gradual disappearance after puncture of the dura. The edema in this case was supposed to be inflammatory and the result of suppuration about the distended area of the dura. Unfortunately, the manner in which the limitation was produced is not known, but a case reported by Musser, Martin, and myself[10] offers a suggestion in this regard. A cyst formed by the pia produced the symptoms of spinal tumor, and when this cyst was ruptured at the operation, a great gush of the cerebrospinal fluid dammed up above occurred. It is not improbable that in sharply limited spinal serous meningitis inflammatory adhesions occur between the dura and pia and form an obstruction. Packing the wound for three days, in Krause's case, with iodoform gauze permitted the dura to be punctured without infection of the pia. Surgeons should bear in mind the possibility of spinal serous meningitis alone or complicating other processes, therefore not necessarily traumatic.

Regeneration of the spinal cord after injury is a subject of dispute among investigators at the present time. Trendelenburg[11] recently has stated that he failed to obtain any regeneration in dogs after cutting and suturing the spinal cord. Examination showed a mass of cicatricial tissue in the gap caused by the retracted ends. Sacki and Schmaus[12] have presented the subject of regeneration of the cord as it appeals to the majority of conservative students. In rabbits after division of the cord regeneration of nerve-fibers occurs. Delicate, young, often medullated nerve-fibers may be seen passing from the posterior roots into the tissue between the stumps of the cord, likewise fine fibers growing from the white matter of the cord into the scar tissue. These new-formed fibers have many of the characteristics of young peripheral nerve-fibers, such as neurilemma sheaths with elongated nuclei. The new fibers have a tendency to follow the blood-vessels, even within the perivascular lymph-spaces, but they do not cause reunion of the ends of the cord and restoration of function. The formation of new fibers is slight, limited to a small area, and the fibers do not penetrate the scar tissue. Restoration of function by this means is impossible.

A few cases are known in which symptoms of a transverse lesion of the cord have disappeared, and examination of the cord has shown a formation of new nerve-fibers in the sclerotic tissue. The condition was compression myelitis. The restoration of function may have been by recovery from pressure by edema and by vicarious action of other fibers that were not destroyed, but nevertheless the fact remains that in a few cases true regeneration of nerve-fibers occurs and plays an important rôle. In the cases of compression myelitis where the sclerotic tissue occupies only a small area, the young nerve-fibers have been traced following the blood-vessels, even leaving the cord in the anterior fissure to avoid the degenerated area, and entering the anterior horns below the level of compression. In this way union of the anterolateral columns above the lesion with the anterior horns below the lesion has been established. When the blood-vessels are preserved, as in compression myelitis, a means of communication is open to the young nerve-fibers, but when the vessels are destroyed, as in section of the cord, the nerve-fibers have not this course of least resistance, and they cannot penetrate the scar tissue, just as dense scar tissue in peripheral nerves prevents reunion. Even in the most favorable cases the number of new-formed fibers is small.

Thus it will be seen from Sacki and Schmaus' presentation of the subject that regeneration of the spinal cord sufficient to cause restoration of function is improbable. The nerve-fibers that are formed seem to be chiefly, if not entirely, of the peripheral type, *i. e.*, they have neurilemma sheaths, and probably do not originate within the cord, and could hardly extend far into it. In compression of the cord many nerve-fibers lose their medullary sheaths, and the naked axis-cylinders remaining are still capable of function. In this way, doubtless, much restoration of function occurs. A recent and conservative discussion of the subject of regeneration of the spinal cord is from the pen of L. Pierce Clark,[13] but views quite different from those expressed by Clark are advanced by Haynes.[8]

The case of Stewart and Harte[14] is unique in the literature; a few cases, somewhat similar are unconvincing.

ABSCESS OF THE BRAIN.

Abscess of the brain may be secondary to some suppurative process in a remote part of the body, especially in the lungs, or to a similar inflammation of the skull. The blood sinuses within the skull are frequently the primary seat. The cerebral abscess is likely to be near the original seat of infection; thus in disease of the ethmoid sinuses the abscess is more frequently found in the frontal lobe. The most common source of cerebral abscess is purulent otitis media, and the secondary abscess is most likely to be found in the temporal or cerebellar lobe of the same side. Experience seems to show that the temporal lobe (Plate IX) is usually affected, but some regard the abscess of the cerebellar lobe (Fig. 510) as more common. The infectious material is probably carried from the middle ear by the lymphatics or blood-vessels, or possibly it may enter the brain along the acoustic or facial nerve. Abscess of the brain may follow a wound of the scalp or purulent disease of the orbit, and occasionally the primary wound may be so small as to be overlooked. The abscess may be confined by the pia and lie between it and the brain, in which case it is likely to be at the base of the brain, as in the cerebellopontile angle, and is part of general suppurative meningitis.

Usually the abscess within the brain is separated from the cortex by a layer of brain tissue. It may vary in size very greatly, from a few millimeters to several centimeters in diameter. It not infrequently bursts into the lateral ventricle or through the cortex; in the latter case it gives origin to a purulent meningitis. The abscess is often, but not always, defined by a distinct membrane which does not invariably arrest its growth, as it may be broken through by extension of the process. The most common microörganism seems to be the streptococcus pyogenes aureus or albus. The pus is usually thick, and sometimes does not escape at operation, even though the abscess may have been punctured; this failure of evacuation may be due partly to the multiplicity of the abscesses, as when only a small abscess has been penetrated. Cerebral abscesses often are multiple, or an abscess may have several pockets. It is exceedingly doubtful whether spontaneous healing of a cerebral abscess ever occurs, but such a result is believed by some to be possible. Friedman[15] has seen in experimentally produced abscesses

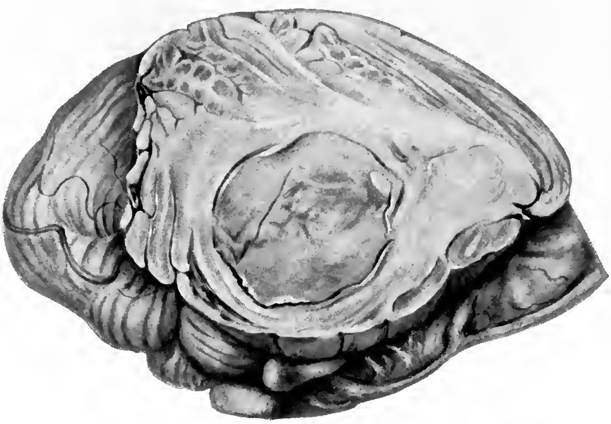


Fig. 510.—Abscess of the Right Cerebellar Hemisphere.
Resulting from a purulent clot in the posterior inferior cerebellar artery. The enlargement of the artery by the thrombus is shown in the illustration.

the limiting membrane appearing within eight to twelve days. It is formed by connective-tissue cells arranging themselves in a layer where the destruction of tissue and inflammation are less intense. It is undetermined whether red softening or suppuration is the primary process within the abscess, but, according to Friedman's experimental researches, cocci are found in the blood-vessels, capillary hemorrhages occur, and pus-cells are soon mingled with the red blood-corpuscles and extend still further into the tissues, edema with softening and rarefaction of the brain tissue follows, leukocytes collect in the small areas of softening, the capillaries become prominent, and the neuroglia cells soon swell. The small abscess cavities unite, and the brain tissue included within them degenerates, softens, and disappears. Fatty, granular cells are numerous. After nine to ten days the limiting membrane consists in the innermost portion of round-cells, blood-vessels, fatty granular cells, and degenerating tissue. A second layer is more vascular and contains

PLATE IX.

ABSCESS OF THE OCCIPITO-TEMPORAL LOBE OF THE BRAIN. The abscess is surrounded by cerebral tissue.

numerous spindle-cells, showing a tendency to a more or less parallel arrangement, but also crossing one another irregularly. In a third outer layer the nerve-cells are degenerated, the blood-vessels are surrounded by round-cells, the neuroglia cells are swollen, and the tissue passes gradually into the unaltered structure about it. The spindle-cells are derived from cells of the vessels' walls, processes of the pia, and wandering cells. Essential differences in the purulent and non-purulent encephalitis are: the greater intensity and rapidity of the process in the former, and the extravasation of round-cells and of pus-cells is much greater. Modifications in the abscess membrane, as just described, occur.

Barr and Nicoll[16] believe that the cause of death after operation in many cases of cerebral abscess is thrombosis of the veins of Galen, with distention of the ventricles and edema of the brain. These lesions may rapidly follow the operation or may be delayed for weeks or months, even when recovery from the effects of the abscess is supposed to have occurred. A very good example of thrombosis of the straight sinus (the continuation of the veins of Galen) with secondary hemorrhage into the lateral ventricles and rapid death is given in the section on Intracranial Hemorrhage (Fig. 505), although abscess was not present in this case.

TUMOR OF THE BRAIN.

A tumor of the brain may be a sarcoma, fibroma, glioma, endothelioma, gumma, tuberculoma, carcinoma, cholesteatoma, lipoma, psammoma, enchondroma, or mixed forms of these growths, such as osteosarcoma, myelosarcoma, fibrosarcoma, etc. The most frequent is probably the **sarcoma,** and this may occur at any age. These tumors are often well defined from the surrounding brain tissue, although sometimes they are infiltrating. They may be cystic, and the cyst may be either close to or within the tumor. I have known a tumor of the brain, in a case under the care of Dr. C. K. Mills and seen by me in consultation with him, and removed by Dr. Keen, to have a cyst beneath it like the finger of a glove (Fig. 511). Many sarcomata are very vascular—telangiectatic. Not a few undergo degeneration, and become softened at one or more parts. The growth is composed of cells with very little intercellular tissue, and usually is of rapid development. Occasionally a sarcoma may grow very slowly, resembling a glioma. The cells are round or spindle-shaped, large or small, and may be associated with giant-cells with many nuclei. Some tumors contain a large amount of dark-brown pigment—melanin—which appears under the microscope somewhat as foreign matter from the stain. These melanotic sarcomata are very malignant and are metastatic. Sarcomata are often multiple, and may be in the spinal cord as well as in the brain. More rarely the process assumes a diffuse form and is a sarcomatous meningitis. In this variety several soft tumors may be found at the base of the brain, and I have seen the optic chiasm and each Gasserian ganglion embedded in sarcomatous masses, with small tumors at other parts of the base of the brain, and innumerable small tumors, the size of a pin's head or a little larger, throughout the spinal pia. Most of these tumors give no symptoms, as they are exceedingly soft and cause little or no pressure or destruction of nervous tissue. Their occurrence is, therefore, important for the surgeon to recognize, as he is liable to forget them in making his clinical diagnosis. Cranial nerves or spinal roots may pass unaffected through these soft tumors (Fig. 512). They are usually confined to the pia, but I have seen extension into the spinal cord, and in one instance a large sarcoma filling up the center of the cord and leaving only a narrow band of cord tissue about it. Its mode of development by means of the anterior pia septum was easily determined.

Fig. 511.—Sarcoma of the Brain with Cyst beneath it Like the Finger of a Glove (Mills, Keen and Spiller).

Removed at operation. Patient lived about four years after the operation, and was very much benefited.

The *alveolar sarcoma* is distinguished by an arrangement of the cells in nests separated from one another by delicate bands of connective tissue, the whole resembling somewhat a carcinoma.

A sarcoma may originate within the bones of the skull and affect the brain by pressure or by direct extension into it. The Gasserian ganglion may be embedded in the tumor, and the pain produced in this way may be intense.

Some of the tumors growing from the bone belong to the **osteosarcomata**. They may often be easily recognized by the prominence they cause upon the exterior of the skull or within the nasopharynx. I have seen a large tumor detected by examination of the nasopharynx extend within the cranium into the base of the temporal lobe and embed the Gasserian ganglion within it. Tumors of the latter structure are rare, but produce such intense pain in the distribution of all three branches of the trigeminal nerve, the symptoms beginning with associated paresis in the motor distribution of this nerve, that the diagnosis usually is not very difficult.

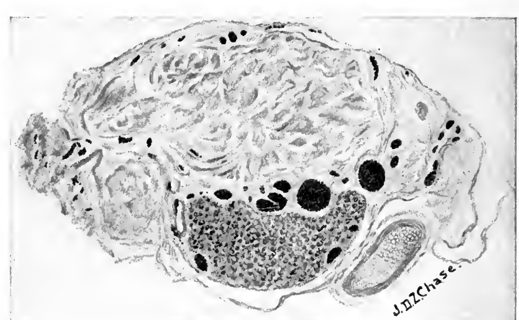


Fig. 512.—Soft Sarcoma Surrounding a Spinal Root. The latter is shown by deeper shading.

Sarcoma within the brain substance may undergo calcareous degeneration. Sarcoma of the skull is often very vascular, and if operated upon, the hemorrhage may cause the surgeon great annoyance, as there is no means of compressing the vascular diploë. Sarcoma growing within the brain may penetrate the dura, and by pressure wear away the inner portion of the bone of the skull. When originating in the dura, the

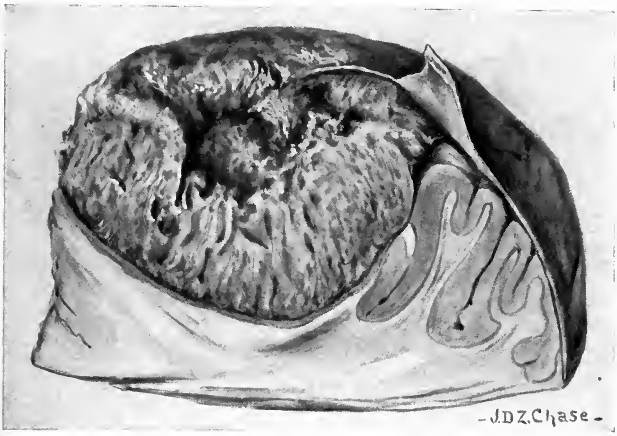


Fig. 513.—Endothelioma of the Brain.

The atrophied cortex is shown beneath the tumor. The tumor does not project beyond the surface of the brain, and the space it occupies has been obtained by atrophy of the brain. It is not infiltrating.

tumor often causes atrophy of the portion of brain underlying it, and appears to form a part of the brain, but careful examination will show that it may be easily separated from it, and the thinned-out cortex may often be seen beneath the tumor (Fig. 513). Microscopic study will be likely to show some cellular infiltration of the adjacent brain, even though the differentiation may appear sharp to the naked eye. Many of the tumors with this origin belong to the endotheliomata. These tumors grow from the endothelial lining of the dura, or of the perivascular spaces or lymphatic channels. They belong to the sarcomata, but their cells have more the arrangement in columns or bands. Occasionally they may cover the inner surface of the dura in the form of minute nodules resembling the tubercles caused by the tubercle bacillus, as in a case reported by Dercum, Keen, and myself.[17] The bone over an endothelioma may be much thickened without infiltration of tumor cells (Fig. 514).

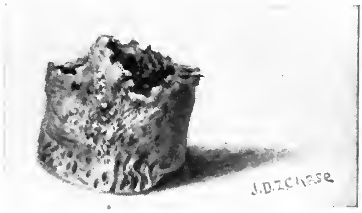


Fig. 514.—Actual Thickness of Bone over an Endothelioma in the Upper Part of the Brain and not Infiltrating the Skull.

All parts of the brain may be affected by sarcoma, and it may even grow within the ventricle, occasionally extending from the wall of the lateral ventricle. I have in several instances seen the entire fourth ventricle filled by a sarcoma. The tumor may be so small that it may be difficult to discover it even by microscopic examination, as in a case I have recently studied where, from the symptoms, among which was paralysis of upward associated movement of the eyeballs, I believed a lesion must be near the aqueduct of Sylvius, and a minute sarcoma was found in this region, but only by microscopic examination. When growing in the cerebellopontile angle, they are often entirely separate from the adjacent brain tissue, and sometimes are kept in position with difficulty when the brain is removed. They seem to have a tendency to grow from the acoustic nerve, as a consequence of which deafness is often an early symptom. Tumors in the cerebellopontile angle are frequently fibromata or fibrosarcomata, and therefore relatively benign, and from their character favorable for operation, although they cause the surgeon much difficulty in their removal because of their almost inaccessible position. The greater frequency of sarcoma and glioma in the cerebrum is due in large measure to the greater mass of this part of the brain.

Sarcoma is not so unfavorable a tumor for operation as might be supposed. It is unquestionably malignant, but it may not be so dangerous as the glioma. It is often well defined from the surrounding tissue, and may in some instances be shelled out from the brain by the surgeon's finger, although small masses of cells are usually left behind from which a new tumor may develop. Several years may elapse before a second operation is necessary. Sarcoma is often near the upper part of the brain, therefore in an accessible region, and when growing from the dura is frequently readily separated from the adjacent brain, but, unfortunately, these dural tumors are often very vascular, and death is caused at operation by uncontrollable hemorrhage. Sarcoma of the brain is usually primary and solitary, and when metastatic, is likely to be multiple, but in the great majority of cases the sarcoma originates in the brain, and is not likely to give metastasis to other parts of the brain or of the body, but occasionally may do so. I have never observed a case in which sarcoma of remote parts of the body seemed to have had its origin from a sarcoma of the brain, although I have seen multiple tumors of the brain and cord having their origin from one large cerebral growth. The dissemination is probably by the cerebrospinal fluid.

Sarcoma growing at the base of the brain may sometimes distort the brain very greatly, and I have seen the pons and medulla oblongata pushed very much aside. When the sarcoma has developed within a cerebral hemisphere, I have seen great distortion of this hemisphere, so that the corpus callosum and the basal ganglia may be pushed forward or backward according as the tumor is in the occipital or frontal lobe; or the median surface of the hemisphere containing the tumor may become convex and make a concave nest for itself in the median surface of the adjacent hemisphere.

Softening is not uncommon about a sarcoma, and is caused by the pressure from the tumor interfering with the circulation of the blood in the surrounding tissue. It is much more likely to occur in sarcoma than in glioma, as the latter does not cause so much pressure on the adjoining tissue, being of an infiltrating character.

Fibroma develops usually at the base of the brain and grows from the dura. The tumor may be hard or soft, according to the number of cells it contains, but is usually very firm. The association with sarcoma, forming fibrosarcoma, is common. These tumors present irregular nodules upon the surface and often are more or less spheric (Fig. 515). They may sometimes attain a very large size without causing many symptoms. I have observed a fibroma as large as a billiard ball growing from the base of the skull and invading the lower part of the occipito-temporal lobe, yet causing scarcely any symptoms. The growth of a fibroma is slow, and the brain accommodates itself to it. Multiple fibrosarcomata may

Fig. 515.—Fibrosarcoma Growing from the Dura at the Base of the Brain in the Left Cerebellopontile Angle.

be found of varying size, from that of a pinhead to that of a walnut or even larger, and these tumors in any one case may be very numerous.

Psammoma, containing the brain-sand, such as is found normally in the pineal gland, develops in this gland or in the choroid plexus.

Cholesteatoma is a very rare tumor, and I have met with it but once. It presents a mother-of-pearl appearance, and if pieces of the tissue are examined in the fresh state or even after they have been hardened, by mashing them under a cover-glass, cholesterin plates may often be seen, presenting the peculiar rhomboid form with a broken corner. The cholesteatoma is of very slow growth, causes, therefore, as a rule, few symptoms, and usually compresses without infiltrating the brain.

It develops at the base of the brain or on the median side of a cerebral hemisphere.

Dermoid cysts and **lipomata** are curiosities when occurring in the brain, so extremely rare are they. Enchondroma is also an unusual tumor of the brain.

Carcinoma of the brain may be primary when growing from the pituitary body, but usually is secondary to carcinoma elsewhere in the body, especially in the mammary gland, lungs, or bronchi. It is considered a rare tumor, but I have found it several times. In one of my cases where carcinoma was found in the prostate gland, liver, ribs, etc., numerous carcinoma nodules of different sizes were found on the inner surface of the dura (Fig. 516), and one large tumor about the size of a walnut invaded the brain. In another case the carcinoma surrounded the optic chiasm and optic nerves. In still another case the carcinoma nodules were so numerous they could hardly be counted. Carcinomata being metastatic in the brain, are usually multiple. They afford little opportunity for surgical intervention because of their multiplicity both in the brain and other parts of the body. Sometimes the primary lesion may be overlooked, as when in a bronchial gland, or it may have been removed by operation before any cerebral symptoms occurred.

Fig. 516.—Numerous Carcinoma Nodules on the Inner Surface of the Cerebral Dura.

Glioma is a common tumor of the brain, and comes second to sarcoma in frequency, in my experience. It is almost always solitary, arises primarily in the brain, and is infiltrating. Occasionally a glioma has been observed well defined from the surrounding tissue, but such an occurrence is most unusual. Glioma presents more an embryonic type of neuroglia, and the forming cells push their way into the brain tissue, so that it is impossible to define the tumor by the naked eye, and almost impossible to do so with the microscope. They are very vascular, and hemorrhage into a glioma is not of rare occurrence, causing a sudden increase in the symptoms and not rarely death. Many nerve-cells and nerve-fibers inclosed within a glioma may escape destruction, and axis-cylinders deprived of myelin sheaths may pass through the tumor. It is, therefore, not uncommon to find the tumor much larger than one might be led to expect from the symptoms. In a case of large glioma of the pons I have been greatly impressed by the very moderate amount of secondary degeneration below the tumor, even by the Marchi method. Gliomata cause few symptoms by pressure, inasmuch as they are infiltrating tumors, but their symptoms are produced by actual destruction of tissue. Surgical removal of a glioma is likely to cause an increase in the symptoms, as the many nerve-fibers passing through the tumor and yet preserving their function are destroyed by surgical intervention, and this is one of the serious objections to operation. A glioma is not infrequently in the cortex or white matter of a cerebral hemisphere, and the pons also is a favorite seat. The surface of the brain may show little evidence of a tumor; the color of the glioma may be the same as that of the adjacent healthy brain tissue, but the convolutions may be enlarged and the sulci shallower. I have seen a glioma lead to enlargement of one side of the pons and cause a mushroom-like growth beyond the limits of the pons. Gliomata may be extremely difficult to recognize at operation, and a uniform enlargement of the part may be the only means of determining the existence of the tumor, even when it is fully exposed. Glioma is often cystic, but, as previously said, less likely than sarcoma to cause softening of the adjacent tissue. It seldom breaks through the pia. It is a question whether the surgeon would not be acting wisely to decline to operate upon a glioma. He may find it impossible to determine that he has to deal with this growth, but he may be able to recognize that it is infiltrating and probably therefore a glioma. Sarcomata sometimes also are infiltrating. By attempting the removal of a glioma he may increase the symptoms, by destroying the normal fibers passing through the tumor; he will be almost certain to leave a part of the growth behind, as he cannot determine its limits, and this remaining portion will develop all the more rapidly because of the space afforded by removal of a portion of the tumor, and because of its increased vascularity. Improvement for a period is sometimes observed after removal of a glioma, but I am beginning to think that the best surgical treatment for a glioma would be a palliative operation, viz., merely opening the skull to relieve pressure.

Tuberculosis of the brain is of little surgical importance at the present time. The tuberculous meningitis with numerous miliary tubercles is beyond the surgeon's skill. Solitary tubercles occur, but they are almost invariably associated with other manifestations of tuberculosis in the brain or other organ. Sometimes tuberculous meningitis develops in plaques confined to the motor region of one side, as in a case reported by Frazier and myself, where it was limited to the parietal lobe (Fig. 517). This condition being sharply localized, may cause the symptoms of brain tumor, and so distinctly was this true in our case that an exposure of the brain was made. This was probably the first case of the kind reported in America. Solitary tubercles are most frequent in children, and are found especially in the cerebellum, pons, and basal parts of the brain.

What has been said of tuberculosis of the brain is true in great measure of **syphilis.** The process is diffuse and seldom gives an opportunity for surgical intervention, but occasionally a gumma may form and cause localizing symptoms demanding operation; or the bone of the skull may undergo local proliferation, justifying the removal of a part of the thickened region to relieve the pressure upon the brain, as in a recent case under my observation, where the bone was three-fourths of an inch thick in the upper part of the frontal region. Gumma is not a common tumor on the necropsy table, and I am convinced that the diagnosis of gumma is made far too frequently. *The common lesions of syphilis of the nervous system are arteritis and meningitis,* and these may cause localizing symptoms as truly as does gumma. The bones of the skull are not infrequently affected by syphilis in the early as well as the late stages. The frontal and parietal bones are most likely to be implicated, and soft granulation masses may form on the outer portion of the skull, at first semifluid. This swelling may disappear under antisyphilitic treatment, or it may become ossified and cause a hard bony enlargement of the skull. The swelling may be irregular in outline, or cause a uniform enlargement of the affected bone. The skull at the seat of the syphilitic process undergoes more or less osteoporosis, causing numerous minute cavities, and this process is associated with the formation of new bone. The bone may be implicated in its entire thickness, and the process may invade the underlying dura, so that the latter becomes very adherent to the skull and shows granulation tissue. The syphilitic inflammation may extend inward and implicate the pia and brain substance. The enlargement does not always become sclerotic. A gumma may form in the bone, possibly having its origin in the dura, may lead to absorption of the overlying skull, and, after penetrating it, form a large tumor mass on its outer surface. Pieces of bone may be separated by granulation tissue and undergo necrosis and act as a source of irritation.

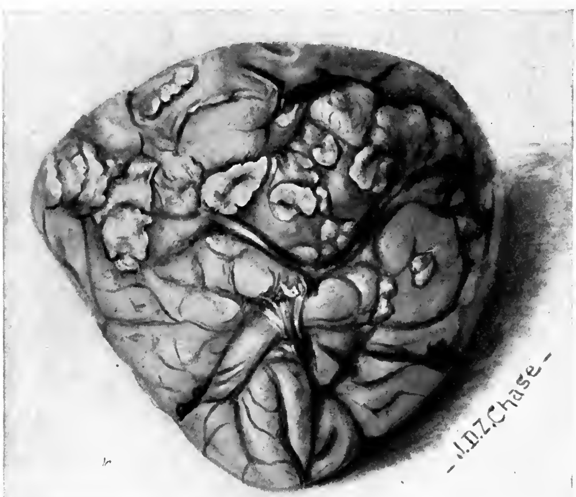


Fig. 517.—Tuberculosis in Plaques on the Parietal Lobe Causing the Localizing Symptoms of Tumor.

Internal hemorrhagic pachymeningitis may be caused by syphilis, and I have observed one case in a child where the new membrane extended over both hemispheres of the brain.

EPILEPSY.

A distinction has been made between the cases of so-called symptomatic and idiopathic epilepsy, and yet it should be remembered that this differentiation is not always sharp. It is much the same as between organic and functional disease. It is impossible to believe that severe convulsions may persist during a long period without organic change in the brain, although one may easily imagine that from toxic conditions changes may occur in the cortical nerve-cells, undetectable by any means at our command at present, which would be sufficient to produce convulsions; yet one would suppose that in such cases sooner or later recognizable changes would be produced.

There are many instances of epilepsy with marked gross alteration of the brain where the cause is clearly in evidence, but all the changes found are not always responsible for the epileptic condition. Slight diminution in the size of the cortical gyri, possibly congenital, cannot produce spasms. If the brains of many epileptic persons are examined, lesions of pronounced intensity will be found in a certain number. Where the convulsions have existed only a short time, the lesions may be of recent development; thus we may expect to find acute encephalitis or hemorrhage on or within the brain, sometimes single, sometimes multiple; or thrombosis or embolism of blood-vessels, cutting off the nutrition of a certain area of the brain and leading to irritation and softening; or the lesion may be more diffuse, such as serous meningitis (internal hydrocephalus) or some other form of meningitis. Congestion of the brain and increased intracranial pressure, as from tumors, are probably causes. Trauma frequently leads to epilepsy, and does so by producing such lesions as those just described. A piece of fractured bone resting on the brain is often a source of intense irritation. Rupture of the middle meningeal artery not infrequently is of traumatic origin and causes a large clot pressing upon the brain.

The lesions of chronic epilepsy may be those described, but often they present the late stages of such organic change. Hemorrhage at birth from difficult labor is a common cause. A scar may be all that is left of a previous hemorrhage or area of softening. The degenerated tissue has been absorbed, the surrounding normal tissue has contracted, and a scar formed by contracted neuroglia results, often stained by blood-pigment; or there may be a cyst. The internal hydrocephalus associated with external hydrocephalus may be of a very high degree, and the brain may become a mere sac filled with cerebrospinal fluid. I have seen the white matter and cortex on the upper surface of the brain not over a quarter of an inch in thickness in hydrocephalus. The whole distribution of the middle cerebral artery may be sclerotic, or the cortical areas of sclerosis may be small and numerous. In some instances enlargements in small areas in tuberculous form (tuberculous sclerosis) are found, but this is a decidedly uncommon condition, and is more likely to occur in the congenital cases and in feeble-minded persons. Porencephalia, a cavity extending inward from the surface of the brain and sometimes opening into the lateral ventricle, is a source of the irritation producing convulsions, and this cavity is caused probably by some intra-uterine or early formed extra-uterine lesion, such as hemorrhage or softening. The brain in congenital cases may be extremely deformed and hardly recognizable as coming from a human being. I have known intense internal hemorrhagic pachymeningitis in a child to cause epilepsy.

The motor area of the cortex probably must be implicated in order that convulsive movements may arise, but the lesion need not be in or near this region; it may be in the basal ganglia, pons, or medulla oblongata. The increase of intra-cranial pressure produced by such a lesion may be responsible for the involuntary movements, and yet it is probable that in some cases the explanation is to be sought in the transmission of the irritation by some other means, or through the nerve-fibers of the encephalon. Sclerosis of the cornu Ammonis has been described in some cases of epilepsy, and it undoubtedly occurs.

The Jacksonian form of epilepsy, in which the convulsion begins in the same part and may be confined to one or both limbs of one side, is of great diagnostic importance, and usually is indicative of some focal lesion in or near the motor cortex of one side. It has been observed, however, in the so-called idiopathic epilepsy. Tumor of the brain is one of the most important causes of Jacksonian epilepsy, but any focal lesion may produce it. Sometimes the lesion is an abscess. Parasitic cysts of the brain are rare, especially in this country. Diffuse lesions, like syphilitic or tuberculous meningitis, may cause Jacksonian epilepsy by greater intensity of the lesions near the motor cortex.

The finer changes of the brain are sometimes detected with difficulty. Much has been written in regard to gliosis of the cortex (Chaslin), and in some cases small masses of matted neuroglia fibers are found in the cortex and extend through a large area.

The capillaries of the brain may be much thickened; I have even seen them calcified. Where the process is more intense, the large vessels of the brain may also be sclerotic, but it is important to know that the capillaries alone may be thickened. Epilepsy is not an uncommon manifestation of cerebral arteriosclerosis. It is probable that the repeated congestion of the smaller vessels leads in course of time to thickening of these vessels, and, indeed, the convulsions may be the cause instead of the effect of some of the lesions found in the brain. I have known hemorrhage of the face or of the conjunctiva of the eyeball to occur as a result of epileptic convulsions; it is seen also after the spasms of pertussis, and it is only reasonable to believe that occasionally similar conditions may occur in the brain.

Numerous cellular changes have been described as occurring in the brains of epileptics. The status epilepticus, with the congestion of the cerebral blood-vessels, is responsible for many of these minute cellular alterations. Chromatolysis, displacement of the nucleus, tumefaction of the cell-body, loss of or rupture of the dendritic processes, have been described. Some of these changes occur normally in the brain, and others unquestionably are artefacts, but when in great intensity or widespread, they are probably pathologic. It does not follow that they are the primary source of cortical irritation. The rise of temperature in status epilepticus may be responsible for some of them, and other causes are certainly hydrocephalus, arteriosclerosis, increased intracranial pressure from any cause, etc.

John Turner's[18] recent study of the pathology of epilepsy leads him to the conclusion that epilepsy is a disease occurring in persons with a defectively developed nervous system, associated with a morbid condition of the blood, whereby it shows a special tendency to intravascular clotting, and the immediate cause of the fits is sudden stasis of the blood-stream resulting from the blocking of cerebral vessels by these intravascular clots. Turner believes that the study of the central nervous system in epileptics shows that changes in the nerve-cells are generally to be found.

The summary of his findings is as follows: (*a*) A form of cortical nerve-cell indicative of imperfect development; (*b*) retention of subcortical nerve-cells, also indicative of imperfect development; (*c*) either an acute form of cell change, similar to that produced by ligature of the cerebral arteries in a dog; or (*d*) groups of darkly stained, shrunken cells, representing a more chronic change, and very probably, at all events in some cases, the sequel of that just described; (*e*) large numbers of blood-plates in the blood; (*f*) different forms of intravascular clotting, probably in large measure derived from amalgamation of the blood-plates, but to some extent also probably due to destruction of red blood-corpuscles; (*g*) small cortical hemorrhages which, in some cases, can be traced to rupture of a vessel blocked by the aforementioned clot.

There is great difficulty in deciding whether these changes are to be regarded as cause or effect. In the discussion of this paper at the meeting of the British Medical Association in Toronto (1906), when it was again presented, Turner said his examinations were made from the chronic cases in the hospital. One may readily believe that repeated convulsions, with the congestion caused thereby, might produce intense alteration of the small cortical vessels and nerve-cells. This objection is to be raised against all the findings of cellular changes in epilepsy reported by others.

TIC DOULOUREUX.

Much caution is needed in ascribing tic douloureux to cellular changes in the Gasserian ganglion. This has been recently emphasized by Rocco Caminiti,[19] and although he is in error when he says that not more than twenty examinations of excised ganglia have been made, his conclusions seem to be justified. For example, my own investigations[20] on seven Gasserian ganglia, although reported some years (1898) in advance of his paper, have been overlooked, and he includes only the report of two ganglia and of one case of endothelioma of the ganglion reported later. Inasmuch as comparatively few Gasserian ganglia have been examined, although many have been removed, it cannot be said that cellular changes are constant in tic douloureux. They are not constant even in cases in which examination has been made, and when found, they are not the same in every instance. Caminiti points out that similar cellular changes are present when tic douloureux has not existed, and that in certain cases of tic the cause has been found in a tumor of the pons, aneurism of the carotid, or tumor of the brain causing pressure upon the ganglion.

It could hardly be expected that the sole cause would be found in cellular changes within the ganglion, nor has it been demonstrated that it is always to be sought in the ganglion. The peripheral branches may first be diseased, and the cellular changes may be secondary to, and produced by, these peripheral alterations—a reaction at distance The peripheral nerve-fiber and cell-body are a unit, and one cannot be degenerated for a long time without producing change in the other. It is to be expected that a tumor near or in the Gasserian ganglion, by irritating its nerve-fibers, would cause pain, but usually sooner or later the pressure increases and leads to disturbance in the transmission of impulses, to a loss of function, and painful paralysis ensues; *i. e.*, the irritation causes pain by the impulses sent upward from the lesion, but the latter prevents peripheral stimulation from reaching the brain. Such cases differ clinically from typical cases of tic douloureux.

It is interesting to read what Caminiti has to say regarding the cellular changes supposedly causative of tic douloureux. In normal ganglia the cells are not everywhere equally numerous, they are of different sizes—some are oval and some are round; some have imperfectly formed Nissl bodies; some stain more deeply near the periphery; in some places the capsule is empty, or instead of containing a nerve-cell, a collection of nuclei or a mass of protoplasm is found. The nucleus may be less deeply stained and peripherally situated; the cellular pigment increases with the age of the individual, and is differently situated in the different nerve-cells, and may occupy the greater part of the cell.

Such changes as these have been regarded as pathologic when found in Gasserian ganglia excised in cases of tic douloureux, and are of much less value in Caminiti's opinion than are the changes in the peripheral branches of the nerve or in the connective tissue of the ganglion, an opinion in which I share. Cellular changes are of questionable value. One could hardly dispute the importance of swelling and disintegration of the axis-cylinders, such as I have seen in great intensity (Fig. 518), or the breaking up of the myelin into fine black balls, as shown when the nerve is stained by osmic acid in the fresh state, and yet cellular changes are not to be ignored. They may be pathologic when occurring in many cells of the ganglion and in an intensity beyond the normal. What in slight degree is within the limits of the normal, becomes pathologic when excessive.

In many of the ganglia removed in cases of tic douloureux the vessels have been found exceedingly sclerotic, but as the disease is likely to occur at a period when sclerosis of the vessels is common, it is uncertain whether a relation of cause and effect can be established.

The changes in the nerve-fibers of the ganglia may be pronounced. The medullary sheaths may be much swollen, so that no traces of axis-cylinders remain, or the axis-cylinders may be irregular and separate masses of a hyaline-like red substance (Fig. 518), when acid fuchsin is used, having little resemblance to normal axis-cylinders. Many nerve-sheaths may be entirely empty, or the nerve-fibers may appear much atrophied.

The changes occurring in the nerve-cells of the Gasserian ganglion after operation on the peripheral branches are believed to be more intense and persistent if the nerve-fibers are torn out instead of cut; the former method of operation is, therefore, to be preferred.

The sensory root is usually in good condition in cases of tic douloureux, and possibly it is because of this fact that arrest of pain occurs almost invariably after removal of the ganglion.

Fig. 518.—Swelling of the Axis-cylinders of the Gasserian Ganglion.
From a ganglion removed by Dr. W. W. Keen and examined by the author.

When portions of the peripheral branches of the trigeminal nerve are excised in cases of tic douloureux and examined microscopically, many of the nerve-fibers are found degenerated. If the nerves are teased and stained in the fresh state with a 1 per cent. solution of osmic acid, numerous black balls representing degenerated myelin may be found within the nerve-fibers. These can hardly be regarded as artefacts. Sometimes the small vessels within the peripheral nerves are sclerotic.

Whether the disease begins in the ganglion or peripheral branches is a question that even at this time has not been definitely settled. As already said, alteration cannot exist a long time in the one without sooner or later causing changes in the other, hence the difficulty of deciding which is primary.

TUMOR OF THE SPINAL CORD AND VERTEBRÆ.

A tumor may develop outside the vertebræ, grow through the intervertebral foramina, and develop inside the canal without otherwise implicating the bone. A tumor of the vertebra usually begins in the body of the vertebra, but may originate in the laminæ or one of the processes. Most vertebral tumors are malignant, and are carcinoma, sarcoma, or myeloma.

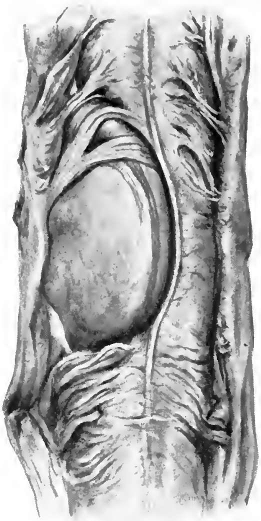


Fig. 519.—Fibroma Compressing but not Infiltrating the Cervical Region of the Spinal Cord.

The extent of this compression is shown in Fig. 520.

Tumors involving the posterior roots lead to degenerative changes within the posterior columns of the cord. Tumor compressing the cord (Figs. 519 and 520) causes impairment or loss of function, partly by disturbance of the lymph- and blood-vessels, and many of the symptoms may disappear when the pressure is removed. It is due to this fact that operations on spinal cord tumors may be very successful—even in severe cases if the delay has not been too great.

Sarcoma is quite frequently found in the vertebræ, and more frequently penetrates the dura than does carcinoma, giving rise to tumors upon the nerve-roots. In my experience sarcoma is more common in the lower part of the vertebral column (lumbar vertebræ and sacrum) and lower part of the spinal cord (Fig. 521). I have seen sarcoma of lumbar vertebræ give origin to numerous sarcomatous tumors upon the cauda equina, and not infrequently they contain minute plates of newly formed bone, so that they are difficult to cut unless decalcified. There may be a single sarcoma or several within the vertebræ. Sarcoma may occur primarily within the cord, as in a case observed by me,[21] but intramedullary sarcoma is rare. Like carcinoma, sarcoma of the vertebræ is usually exceedingly painful, as it is a rapidly growing tumor and presses upon the nerve-roots. Sarcomatosis of the spinal pia has been described under the section on Brain Tumors, and is most pronounced on the posterior part of the cord. Sarcoma may be primary or secondary in the vertebræ. Melanotic sarcoma, fortunately, is rare, and is very malignant. Hart[22] very properly makes the criticism that according to the reports of recovery after operation for spinal sarcoma these tumors in the spinal cord do not possess that extreme malignancy which characterizes them in other parts of the body. He doubts the reliability of the histologic

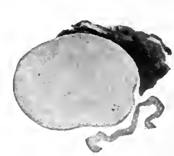


Fig. 520.—Transverse Section of Spinal Cord (Deeply Shaded and Distorted) and of the Tumor Shown in Fig. 519.

diagnosis. It seems not improbable that granulation tissue has been described as sarcomatous.

Harte,[22] from his study of the literature, does not find that extradural tumors are much more frequent and much less fatal than intradural growths. In 50 cases the tumor was extradural, in 36 intradural, and the death-rate in the extradural tumors was higher. Sarcomata he finds are more frequently extradural (of 37 sarcomata, 16 were intradural and 21 extradural). When intradural, they are more likely to be circumscribed or encapsulated; whereas the extradural sarcomata are frequently infiltrating and may involve the spinal column and surrounding muscles very extensively.

Fig. 521.—Sarcoma on the External Surface of the Dura over the Cauda Equina.

Endothelioma of the spinal cord may be solitary or multiple. This tumor seems to be much less common in the spinal cord than in the brain.

Fibroma is rather a common tumor in middle age, and when solitary is, I think, more commonly found in the cervical and upper thoracic regions. It is a hard, slowly growing tumor, and the most favorable of all for operation. It often grows from the pia and compresses without infiltrating the cord, and, once removed, may not recur. It is often mingled with sarcoma, forming a fibrosarcoma. Adjacent nerve-roots sometimes are distorted by the tumor and may pass over or through it. It is usually intradural, and may be multiple, causing numerous enlargements on the nerve-roots, especially in the cauda equina.

Psammoma also occurs, and **myxoma** is supposed to be rather a frequent tumor. Schlesinger regards lipoma as common in childhood, especially when spina bifida exists, but in my experience intradural lipoma is exceedingly uncommon. Any accumulation of fat within the dura, unless in the form of fatty degeneration, is rare. I have observed a lipoma in the filum terminale, and Gowers has seen one in the conus medullaris. Curiosities in the form of tumors are more likely to be found in the lower part of the cord. I have recently observed a tumor in this portion containing striated muscle-fibers and confined within the pia.

Lymphosarcoma, myeloma, and **myoma** are also observed in the vertebræ.

Carcinoma of the vertebræ seems to be always secondary. It may be by extension from contiguous parts, but is usually metastatic from the breast, stomach, prostate, thyroid gland, or uterus, and is supposed to occur especially from the rare primary bronchial carcinoma. It is more common in women, probably because carcinoma of the breast or uterus is more frequent than of other organs, and it is usually in the lumbar or thoracic vertebræ. The entire interior of the body of one or more vertebræ may be replaced by carcinoma. Where several verte-

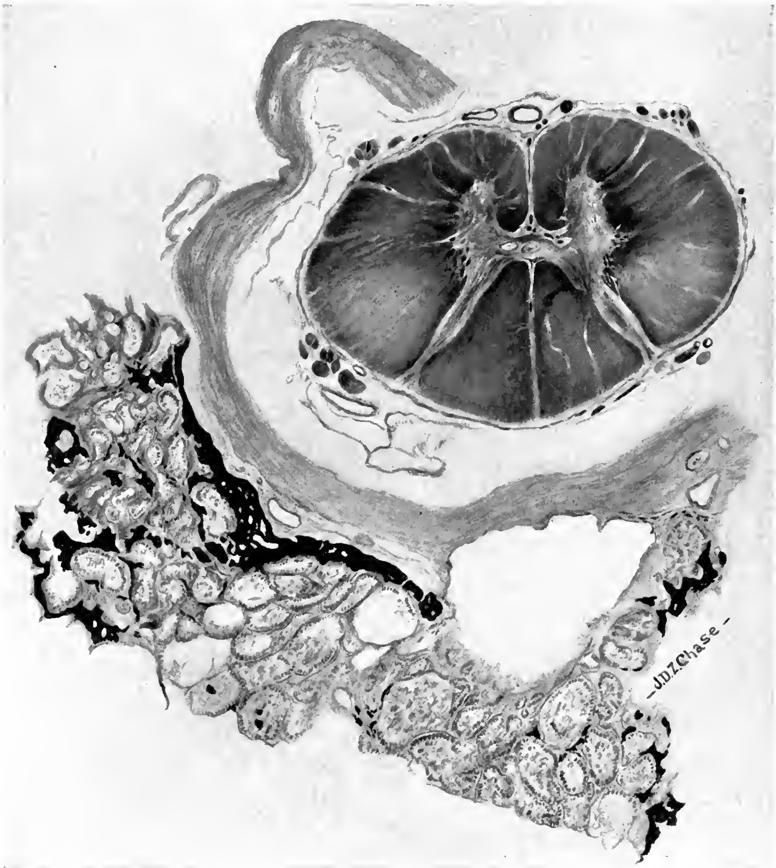


Fig. 522.—Carcinoma on the External Surface of the Spinal Dura not Penetrating the Latter.

bræ are thus affected, displacement causing deformities occurs, or sometimes fractures develop, and pieces of bone may compress the cord, as is seen in tuberculosis of the vertebræ. The height of the patient may be diminished by the implication of many vertebræ. Carcinoma seldom penetrates the spinal dura, and I have seen it form a mass on the outside of the dura much like the tuberculous deposit of caries of the vertebræ (Fig. 522). The dura offers an impenetrable wall to many pathologic processes. Carcinoma of the vertebræ usually is exceedingly painful by pressure on nerve-roots, causing the symptom-complex known as paraplegia dolorosa, but I have known carcinoma of the vertebræ to be comparatively painless. Carcinoma growing between the dura and vertebræ without implication of the latter occasionally occurs.

Myeloma or **myelosarcoma** arises in the medulla of bone and resembles the tissue in which it originates. It leads to destruction of bone from within. It is rare in the vertebræ, and when it occurs here, is part of a more general process. New bone may form within the tumor.

Benign tumors of the vertebræ are enchondroma, myxoma, osteoma, osteochondroma, and exostoses. Osteoma may be multiple. Unfortunately, all are much less common than malignant tumors. I have seen a minute osteoma on one of the sacral roots.

The **cysticercus** and **echinococcus cysts** of the spinal column are very rare in this country. Occasionally non-parasitic cysts formed by the pia may occur, as in the case reported by Spiller, Musser, and Martin.[10]

Tuberculosis may develop as solitary tubercles within the cord or as miliary tubercles of the pia, but is of interest to the surgeon chiefly when occurring within the vertebræ in the form known as Pott's disease. Tuberculous pus and cheesy masses form between the dura and vertebræ and cause compression of the cord. Pressure from a vertebra upon the cord is very rare in spinal tuberculosis. The bodies of two or more vertebræ may become softened and give way, forming a kyphosis. Recently successful operation in cases of tuberculosis of the vertebræ has been reported, with drainage of pus (Harte[22]).

The tuberculous spondylitis may begin in the spongiosa or more rarely in the periosteum. While the affected vertebræ are usually near together, they are not always so, but several foci in different vertebræ may form almost simultaneously. The vertebræ give way gradually, occasionally suddenly, and form a gibbosity. Occasionally the process develops in the laminæ or spinal process instead of in the body of the vertebra, and very rarely in the ligaments without involvement of the bone. When tuberculosis develops in the uppermost cervical vertebræ, the symptoms are like those of tumor of the foramen magnum, and if sudden or even more gradual dislocation occurs, pressure from the odontoid process upon the medulla oblongata may cause death. The tuberculous mass may become encapsulated, partially resorbed, reduced in size by formation of sclerotic tissue, and partially calcified; and the diseased vertebræ may become ankylosed. Some believe, especially Schmaus, that the spinal symptoms in tuberculous caries are chiefly the result of edema from pressure of the pachymeningitis upon the blood- and lymph-vessels. This compression probably also produces anemia.

Syphilis of the cord is very common and occurs as meningitis, myelitis, and arteritis. A macroscopic gumma of the cord is a curiosity. While of great interest to the clinician, syphilis of the cord is of little importance to the surgeon, as he is powerless to accomplish much by operation.

The same may be said of **glioma of the cord,** which is not a rare tumor, but, developing within the substance of the cord, it affords no opportunity for surgical intervention. It may lead to a considerable uniform enlargement of the cord, and often is the cause of syringomyelia.

Syphilitic caries of the vertebræ is uncommon and may be congenital. According to Stroebe,[23] the cervical vertebræ, especially the upper, are affected more frequently, in contrast to the tuberculous caries which usually is lower in the vertebral column. Syphilitic caries may occur in the thoracic and lumbar vertebræ. Stroebe also speaks of the origin of the process as more common in the laminæ or spinal processes than in the bodies of the vertebræ, in contrast to tuberculosis. In the gummatous tissue within the vertebræ and periosteum new bone forms, and, according to Stroebe, is more extensive than in tuberculosis; and dislocation and syphilitic kyphosis may occur. Slight trauma may cause fracture of the vertebræ, but abscess pointing at lower parts as a result of gravity, as in tuberculosis, is not likely to be seen in syphilis. The spinal cord may be compressed by syphilitic exostoses from the vertebræ. Stroebe says that extension of the syphilitic process from the vertebræ to the dura and pia-arachnoid is far less common than extension from the skull to the cerebral dura and the brain. The distinction between syphilitic and tuberculous caries of the vertebræ may be exceedingly difficult, and a microscopic and bacteriologic examination may be requisite before the differential diagnosis can be made.

TUMOR OF NERVES.

Fibroma is probably the most common tumor of peripheral nerves and develops from their connective tissue. This tumor may be confined

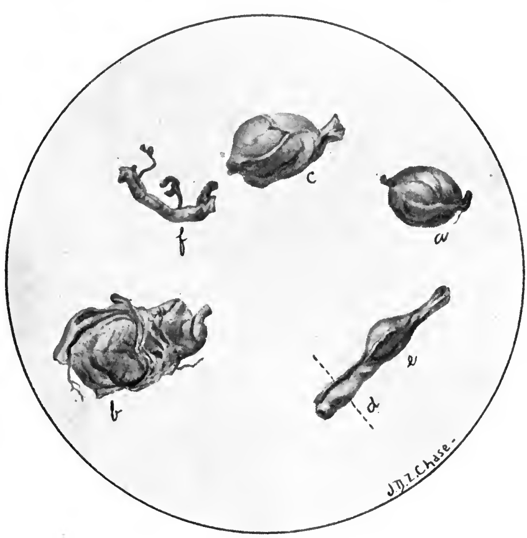


FIG. 523.—ACTUAL SIZE OF THE FIBROMATA REMOVED FROM THE ULNAR NERVE (Keen and Spiller).

to one nerve or may implicate many of the nerves of the body, and may

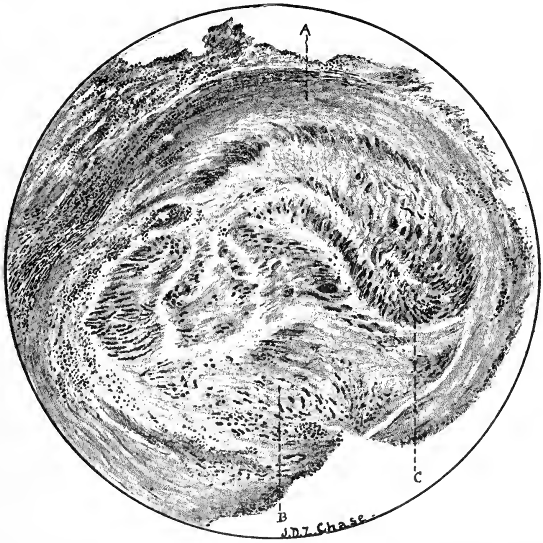


FIG. 524.—TRANSVERSE SECTION FROM ONE EXTREMITY OF THE TUMOR (FIG. 523), SHOWING THE NERVE-FIBERS WIDELY SEPARATED FROM ONE ANOTHER BY PROLIFERATED CONNECTIVE TISSUE (Keen and Spiller).

A, Perineurium; *B*, *C*, nerve-fibers.

develop even on the spinal roots. The intracranial portion of the acous-

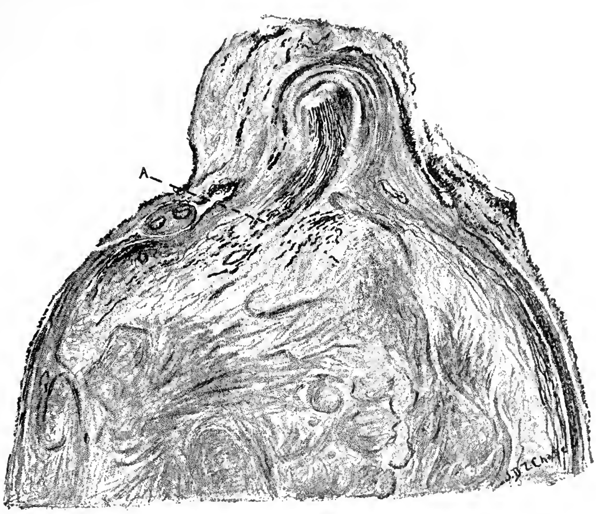


FIG. 525.—LONGITUDINAL SECTION OF THE TUMOR (FIG. 523) (Keen and Spiller).
Showing medullated nerve-fibers entering at one extremity of the growth and passing to the periphery of the tumor (*A*).

tic nerve is sometimes the point of origin of a large fibroma. The tumors may be within the substance of the nerve, as in a case reported by Keen and Spiller[24] (Figs. 523 and 524), in which six or seven small fibromata were found within and inclosed by the fibers of the ulnar nerve, and were shelled out at operation like peas out of a pod. When one of these small tumors was studied microscopically, nerve-fibers could be seen at either end, but not in the middle (Fig. 525). In other bundles of the nerve the connective tissue was proliferated without much destruction of nerve-fibers. The fibroma may grow from a small branch of a large nerve and then be suspended from the latter by a few strands of nerve-fibers (Fig. 526). There is no new development of nerve-fibers in these tumors. The connective tissue in the nerves of certain persons shows a marked tendency to proliferation and gives rise to multiple neurofibromata, plexiform neurofibroma (von Recklinghausen's disease), certain forms of elephantiasis of the skin, or pigment nævi; indeed, a hereditary tendency to such growths has occasionally been observed.

Fig. 526.—Fibromata of a Plantar Nerve (Taylor and Spiller).

Fig. 527.—Amputation Neurofibroma from the Brachial Plexus.

A tendency to sarcomatous degeneration of fibromata of nerves is sometimes seen, and Garrè[25] has found seventeen cases in which sarcomatous degeneration in congenital neurofibromatosis occurred. A discussion on the subject of neurofibromatosis may be found in the paper by Keen and Spiller,[24] already referred to, and in the excellent monograph by Alexis Thompson,[26] that appeared a little later, but in the same year.

Sarcoma is a common tumor of nerves, and may reach enormous size. I have seen the thigh greatly enlarged by a sarcoma developing in the sciatic nerve. Other tumors occurring in nerves may be carcinomata, lipomata, myomata.

The **amputation neuroma** (Fig. 527) is in reality a neurofibroma and one of the best examples of true growth of nerve-fibers. The nerve-fibers from the central stump proliferate in the attempt at restoration of the divided nerve, and there is also overgrowth of connective tissue, pressure from which upon the delicate young nerve-fibers causes the painful stump following operation.

True neuromata are described—tumors consisting of a new-growth of nerve-fibers and not in an amputation stump. I have never been so fortunate as to find one, and am inclined to side with those who doubt their occurrence.

The **neuroma ganglionare** is also very rare, and in some of these tumors the existence of nerve-cells is very doubtful. The nerves-fibers may be medullated or non-medullated, inclosing numerous ganglion-cells, some of which have been described as multinuclear.

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CHAPTER XXXII.

THE SURGERY OF THE NERVES.

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In order to appreciate and understand the pathology and diagnosis of nerve lesions and the requirements of the surgical treatment of lesions of the peripheral nerves, a working knowledge of their structure and function is requisite. A brief résumé of our present knowledge of these follows.

Structure of Nerves.—The essential part of each nerve-fiber is the axis-cylinder, which, if traced centrally in the peripheral nerves, ends in a nerve-cell, of which it is the axis-cylinder process or axone. Peripherally it terminates in the particular tissue controlled by the cell. It is continuous throughout the course of the nerve. According to the character of the further coverings of the axis-cylinder, nerve-fibers are known as medullated or non-medullated, although the same fiber in different parts of its course may be of both kinds.

In a **medullated nerve-fiber** the axis-cylinder is surrounded by the medullary sheath, a protecting and insulating semifluid, fatty medium, whose appearance gives the white appearance to such nerves. This in turn is surrounded by a membranous covering, the neurilemma or sheath of Schwann.

At regular intervals the medullary sheath is interrupted by constrictions, the nodes of Ranvier, where the neurilemma dips in to come in contact with the axis-cylinder, the two latter continuing without interruption at the nodes. The portion between two adjacent nodes is called an internode, and beneath the neurilemma of each internode is an oval nucleus, neurilemma cell or nerve corpuscle, which lies in a depression of the medullary sheath (Fig. 528). The medullated fibers of the brain and cord have no neurilemma, nerve corpuscles, or nodes of Ranvier.

The **non-medullated fibers** are axis-cylinders covered by a delicate sheath beneath which are small nuclei, more numerous than in the medullated fibers. They occur principally in the sympathetic system.

Nerve-cells.—These occur in the ganglia and nerve centers and are of surgical interest in the ganglia of the cervical sympathetic, of the fifth cranial nerve, and of the posterior spinal roots. Nerve- or ganglion-cells are notable for their processes, which are of two kinds, the multiple branched protoplasmic processes or dendrites, and the usually single and unbranching axis-cylinder process or axone. The latter, when unbranched, becomes the axis-cylinder of a medullated nerve-fiber. The nerve-cell with its various processes is called a neurone. The nerve-cells receive through the axis-cylinders the impressions made by external excitants, and send through them impulses to the muscles and secreting organs.

Groups of nerve-fibers are held together by delicate connective tissue (endoneurium) in bundles or fasciculi which are surrounded by a lamellar connective-tissue sheath or *perineurium*. A variable number of such fasciculi are grouped together to form a nerve. This is surrounded by a dense connective-tissue sheath, the *epineurium*, from which septa pass in between the fasciculi, binding them together and supporting the blood-vessels and lymphatics of the nerve. It is this firm epineurium or outer sheath of the nerve that we rely on in nerve suture to hold the sutures, and we endeavor to pass the latter only through this sheath to avoid injury of the nerve-fibers in that form of suture known as "perineural," though properly it should be called epineural. A given nerve-fiber does not remain in a single fasciculus, but groups of fibers pass from one fasciculus to another at frequent intervals.

In general the larger nerves are found to accompany the principal vessels of a given region, and this association is often continued until both nerve and vessel become quite small. There are a few notable exceptions to this rule, as in the case of the sciatic nerve.

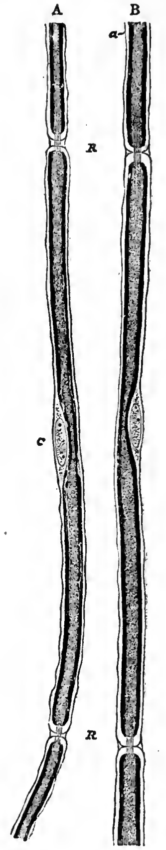


FIG. 528.—PORTIONS OF TWO NERVE-FIBERS STAINED WITH OSMIC ACID. FROM A YOUNG RABBIT (319 diameters) (after Quain).

R, *R*, Nodes of Ranvier, with axis-cylinder passing through; *a*, the neurilemma or sheath of Schwann; *c*, opposite the middle of the segment, indicates the nucleus and protoplasm of the neurilemma cell lying between the sheath of Schwann and the medullary sheath. In A the nodes are wider and the intersegmental substance more apparent than in B (from a drawing by Mr. J. E. Neale).

Physiologic Considerations.—Nerves possess the properties of conductivity and excitability to a high degree. The *excitability* of nerves is shown in their response to various forms of stimulation, such as mechanic, chemic, electric, heat, cold, drying, ether, vibration, etc.

As to electric stimulation, sharp shocks of great intensity, like induction shocks, and especially the "break" induction shock, are more effective than the galvanic current and the "make" induction shock. The impulse is formed at the point of entry on breaking the current and at the point of exit on making it. The positive electrode diminishes excitability.

Conduction of a nerve impulse is the principal function of a nerve. This takes place in either direction equally well at a rate that varies in different nerves. Anesthetics temporarily annihilate this function, probably by dissolving the lecithoproteids or colloids of the nerve. The character of a "nerve impulse" is not definitely known, and its differentiation seems to depend entirely upon the structures in which the fibers terminate.

Degeneration.—The maintenance of a nerve in its normal functional condition depends on its connection with and the integrity of its cell, which exerts a trophic influence upon it. This connection may be interfered with by traumatic, inflammatory, and toxic agencies, such as contusion, compression, stretching, tearing, incision, and the toxic actions of certain poisons. When compression, due to extravasation of blood, inflammatory exudates, or the pressure of tumors, is speedily relieved by absorption or removal, most of the nerve-fibers suffer only mechanic disturbance, and the conductivity is again quickly restored. When the compression is not relieved, local destruction of the nerve-fibers may ensue. In such cases, or when the fibers are severed by tearing or incision, the peripheral portion of the fibers is cut off from the trophic cells and secondary, or Wallerian, degeneration ensues. It occurs whether the ends are sutured or not and in all kinds of nerves. It is best studied when a nerve is divided. The excitability of the nerve, at first slightly increased, is lost in about two days. The motor end-plates in the muscles are affected a little the earliest. (See Vol. I, p. 400, for the histologic pathology of degeneration.) The other two forms of degeneration, the rare primary form, as seen in old age, locomotor ataxia, etc., and the toxic form, which occurs in neuritis, are of less surgical interest.

Regeneration.—Nerves are the only highly specialized tissue which regenerates. The regeneration of nerves is of the greatest surgical interest. There is considerable disagreement as to whether it is due to an outgrowth of the axone from the central stump or to the fusion of this axone with a new axone developed in the peripheral segment by the activity of the neurilemma cells. The proliferation of the neurilemma cells of the distal segment results in the formation of chains or bands of overlapping spindle-cells. Those[1, 2] who believe in peripheral regeneration claim that the nerve-fiber is developed from these chains. According to Ballance and Stewart,[2] the axis-cylinder developed from these chains is at first sinuous and beaded, and remains immature unless it unites with an axis-cylinder of the central stump. They trace the same process through the intervening tissue and in the extremity of the central stump. According to this view the peripheral end of a nerve long divided is regenerated throughout and only awaits being put in such close apposition with the central end that the axis-cylinders may unite and the peripheral regeneration become mature and functional. Secondary nerve suture, therefore, offers hopes of success as long as these immature axis-cylinders survive in the distal segment, and as long as the muscles affected have not become so far converted into fibrous tissue that regeneration of them is no longer possible. Hence the practical importance of this view of "peripheral regeneration." The other view, that the regenerated axis-cylinders and medullary sheaths are outgrowths from the central stump along the course of the degenerated nerve to the terminal endings of the nerve is more in accord with the neurone theory and is strongly upheld, in whole or in part, by many investigators.[3] Two clinical facts, the lack of regeneration, after division, of the axis-cylinders of the spinal cord, which have no neurilemma or neurilemma cells, and the very rapid return of sensation after secondary suture, support the theory of peripheral regeneration.

The process of regeneration takes a varying time. If the central and distal stumps of the divided nerve are too far apart, the process of regeneration fails to bridge the gap, which quickly becomes converted into scar tissue and prevents return of function. Hence the importance of the immediate coaptation by suture of the two cut ends (primary nerve suture) or the later coaptation of the two freshened ends in old cases with loss of function (secondary nerve suture). When union of the divided ends does not occur, either by reason of the distance between the segments, some intervening tissue, or the removal of the distal segment, as in amputations, the central end, and sometimes the distal end as well, becomes bulbous and is known as an end-bulb, amputation neuroma, etc. Within the first few hours after division the nerve-fibers at the central end have curved out and become separated by extravasated blood and migrated cells so as to form the "primitive end-bulb." After the degeneration, which involves the first one or two internodes of the central end, the primitive end-bulb serves as a scaffold on which the end-bulb is built. This consists of new nerve-fibers separated by abundant connective tissue. These nerve-fibers are more numerous than in the nerve itself, for the end of each fiber divides into two or three branches. These end-bulbs are neurofibromata (p. 713).

NEURITIS.

Neuritis is commonly defined as inflammation of nerves. When it is localized in a single nerve, it usually attacks branches of the brachial, lumbar, or sacral plexuses, and is known as an "isolated," "localized," or "simple" neuritis. In such cases there is usually an inflammation of the sheath and the connective tissue extending between the nerve-bundles. This is known as perineuritis or interstitial neuritis, and is the form of most interest to surgeons.

When many peripheral nerves are involved at once, and usually symmetrically, the process is more of a degeneration of the nerve-fibers themselves than of an inflammation, and it is distinguished as a parenchymatous or degenerative neuritis. From the number of nerves usually involved, it is commonly known as "multiple neuritis." In practice these two forms of neuritis, the inflammatory and degenerative, are often found combined, and the product may be termed diffuse neuritis. There are many other terms applied to varieties of neuritis depending upon etiologic factors, such as alcoholic and traumatic neuritis and many others.

"Localized" or "Simple" Neuritis.—Etiology.—This form is often the result of traumatism, such as—(1) The direct wounding of nerves, especially if the wound is infected; (2) contusion of nerves; (3) compression of nerves, from dislocation of joints, fragments of fractured bone, callus-formation, the use of crutches, the pressure of new-growths, or even forcible muscular contractions. It may be due to the contact of the nerve with chemic agents, such as alcohol, ether, osmic acid, through subcutaneous injections. Exposure to cold or the extension of an adjacent inflammation may act as a cause, and it occurs as a sequel or complication of many infectious diseases. Many of the causes of "multiple neuritis" may act as predisposing factors in the etiology of this form, such as alcohol and various dyscrasic conditions, including gout, diabetes, rheumatism, chronic nephritis, syphilis, etc. Neuritis may be due to long-continued pressure during anesthesia for surgical operations, or to the maintenance of an unnatural position, such as the continued elevation of the arms over the head.

Pathology.—In the perineuritis or interstitial neuritis, which is the pathologic condition commonly found in simple neuritis, there is hyperemia with redness and swelling of the perineurium, or increase of the interstitial connective tissue, or both. A serofibrinous exudation with migration of leukocytes follows, and there may be minute hemorrhages. The inflammation may even become suppurative or gangrenous.

The above changes are usually localized in a limited portion of a nerve, but may occur scattered along a nerve-trunk (disseminated neuritis), or they may continuously ascend the nerve (ascending neuritis). In the latter cases the inflammation may reach the plexus in which the nerve arises and thus extend to other or all nerves of the limb. Rarely it has extended to the spinal cord, causing a myelitis. When the process is severe or long continued, the nerve-fibers may become involved and degenerated peripherally, but most often the lesion is limited to the myelin sheaths, while the axis-cylinders are not destroyed and recovery ensues. The nerve-fibers are most apt to be seriously involved by pressure when the nerve is inflamed where it passes through a bony or fibrous canal.

The inflammation, as a rule, begins acutely, but instead of quickly subsiding, it commonly persists in a chronic stage for many weeks or months. In the chronic form there is hyperplasia of the connective tissue resulting in a sclerosis which causes compression and often more or less destruction of the nerve-fibers. Tuberculous and syphilitic neuritis are forms of chronic interstitial or diffuse neuritis which are usually limited to the intracranial portion of the cranial nerves and the spinal roots in meningeal tuberculosis and syphilis. A certain degree of neuritis is commonly present in neuralgia as an etiologic factor.

Symptoms.—While the symptoms vary with the cause, the location and the degree of the lesion, and the character of the nerve, yet in all cases the function of the affected nerve is perverted, exalted, diminished, or lost. In sensory or mixed nerves pain of a stabbing, boring, darting, burning, or shooting character in the course and distribution of the nerve is the principal symptom. This is usually worse at night and increased by movement, and it varies greatly with the intensity of the inflammation. There is usually tenderness along the course of the nerve, and the overlying skin is sometimes red and edematous. The extremity involved may become hyperesthetic. Numbness and tingling are frequent, and tactile sensation is often diminished. If the nerve-fibers are involved, varying degrees of anesthesia may be observed in sensory nerves and of weakness or paralysis in motor nerves, preceded by muscular twitchings and spasm.

If the case is severe and long continued, great atrophy of the affected muscles results and may be followed by contractures. Trophic disturbances in the hair, nails, and skin may occur. The nails become ridged, curved, or fibrous from impairment of nutrition. The skin may become atrophic and glossy, or thickened, as in ichthyosis. The perspiration is occasionally either increased or decreased, and an eruption of herpes or even ulceration occurs in some cases. Perforating ulcer of the foot depends upon a neuritis of the tibial nerves. The ulceration and gangrene, as well as the anesthesia and loss of muscular power, which occur in the course of leprosy, probably depend on leprous neuritis, a very typical form of proliferating chronic neuritis. The faradic irritability, at first increased, is nearly or quite normal in mild cases, but in severe cases it becomes diminished or finally lost, showing the reaction of degeneration when the nerve-fibers undergo degeneration.

Prognosis.—This is usually good in acute neuritis. Traumatic cases, especially those due to a slight traumatism, are the most favorable. If the cause can be removed, acute neuritis may result in recovery in a few weeks. If the disease becomes chronic, the condition may last many months. Those cases with an underlying dyscrasic or toxic condition or a neurotic diathesis are the most protracted. The changes in electric irritability of the nerves and muscles help us in the prognosis by indicating changes in the axis-cylinder processes. When the latter are involved, the paralysis, atrophy, etc., may last for months and even become permanent, unless regeneration occurs. Pain may continue for a long time after the cause is removed.

The **diagnosis** of simple neuritis is usually easy. From neuralgia it is differentiated by the local heat and swelling along the nerve, the paresthesia, the muscular spasm, the paralysis and atrophy, and the trophic lesions of neuritis, as well as by the intermittent character of the pain and the more localized points of tenderness in neuralgia.

Treatment.—The first essential is to remove the cause—the compressing fragment of bone, callus, tumor, etc. Much can be done in the way of prophylaxis in the prompt suture of wounded nerves, the prevention of wound sepsis, and the avoidance of local compression, as in surgical operations and in the use of crutches. In acute cases absolute rest of the affected limb by means of a splint, with elevation and a protective dressing, is demanded. For the relief of pain sometimes an ice-bag, at other times moist heat, is most effective. In addition, counterirritation, as by mustard-plaster, cautery, or blistering, the continuous galvanic current of the strength of six to eight milliamperes for five or six minutes daily, with the anode over the affected nerve, and the use of phenacetin, salol, and other coal-tar products, are serviceable. As the anesthesia present may prevent the patient from feeling and complaining of pain from the counterirritation, care must be taken to prevent unnecessary burns. In severe and persistent cases, and when other means fail, the use of morphin, codein, or opium may be necessary, though a trial of cocain by hypodermatic injection at the seat of pain should first be made. Care should be taken to avoid the morphin and cocain habits. Small doses of mercury, even in cases without a syphilitic history, have been recommended by Gowers to affect the neuritis favorably. The general constitutional treatment of the patient must be looked after by the use of laxatives, diuretics, diaphoretics, antirheumatics, and tonics, especially strychnin. These are especially indicated in chronic cases. For the paralysis accompanying degenerative changes the interrupted galvanic current to the muscles, by improving their nutrition and hastening regeneration of the nerve, is very serviceable. The faradic current should not be used. Massage is contra-indicated during the early period of inflammation, but may be applied later with benefit to the atrophied muscles.

Nerve-stretching has been successfully employed in some cases of chronic neuritis, especially in those cases giving rise to chronic and perforating ulcers.

Multiple neuritis, polyneuritis, also known as disseminated or peripheral neuritis, is a parenchymatous neuritis involving the nerve-fibers of many peripheral nerves at or about the same time and usually symmetrically. As it is of purely medical or neurologic interest, the reader is referred to works of that kind for a description of it.

NEURALGIA.

Neuralgia proper is a neurosis or functional disorder of one or more of the cerebrospinal sensory nerves or their centers, characterized by pain along the course of a nerve or nerves, not due to discoverable organic lesion of the nerve. Probably the majority of neuralgias are not wholly neuroses, but are due in part to irritation of the sensory nerves from without, and many have been proved to be due to neuritis. At the present time it is often impossible to draw the line sharply between these two forms of nervous disorder.

Varieties.—Many recognized forms are symptomatic, or due to some reflex or toxic irritation or organic disease affecting the nerve. Neuralgias are classified according to their cause, as hysteric, reflex, traumatic, toxic, gouty, etc., or according to their location, as superficial, *i. e.*, trigeminal, intercostal, lumbar, sciatic, etc., and visceral. In addition we have the neuralgias of stumps and scars. Headache and migraine do not belong to the class of neuralgias.

Etiology.—As predisposing causes may be mentioned an inherited neuropathic tendency, especially important in trigeminal and intercostal cases, anemia, debility and fatigue, gouty and rheumatic diatheses, and perhaps malaria. Among the exciting causes are toxic substances in the blood, exposure to cold and damp weather, emotional shock, peripheral irritation, injuries, and a low grade of neuritis. Local irritation of a nerve may cause neuralgia of the nerve itself or reflexly of some other nerve; thus a carious tooth may excite trigeminal neuralgia, and a renal calculus, neuralgia of the testis. The great pain occasionally present in scars and stumps is due to the pressure of the end-bulb or of the contracting cicatrix on the nerve filaments caught in it and sometimes requires surgical treatment by excision.

Children under fifteen and old people rarely suffer from neuralgia, except tic douloureux, which is not uncommon in the aged. Women are more susceptible than men in the proportion of five to three. Occupations involving the overuse of muscles, such as running sewing-machines, and exposure to cold and wet, predispose to neuralgia.

Neuralgia may also be due to spinal tumors, caries, and inflammation. As may be noticed, many of the above are causes of neuritis as well as of neuralgia, and in many cases we cannot distinguish between them.

Pathology.—Typical idiopathic neuralgia is supposed to have no discoverable lesion. Not a few cases formerly called neuralgia are now known to be forms of neuritis, *i. e.*, many cases of sciatica and of trigeminal and brachial neuralgia. The degenerative and chronic interstitial changes found in the nerve in some cases of tic douloureux may be either the cause or the result of the condition. Some forms of neuralgia (especially tic douloureux) are sometimes due to faulty nutrition of the nerve from an obliterating arteritis. In other forms the sensory nerves of the nerve-sheath (nervi nervorum) are affected by the diathetic poison of gout, rheumatism, diabetes, and by such extrinsic poisons as alcohol, arsenic, and lead. When the pain jumps from one point to another, we assume that the lesion is in the spinal or cerebrospinal sensory neurons. Sometimes in sensitive patients after the cause of the neuralgia is removed the pain continues as a kind of morbid pain habit of the cerebral cortex. Such hallucinatory or reminiscent neuralgias are apt to occur in those who have used opiates extensively.

Symptoms.—The chief symptom is pain of a sharp, shooting, stabbing, boring, or burning character, which recurs periodically in paroxysms of great intensity. These paroxysms may recur at long or short intervals, but during an attack they are apt to be repeated every few minutes for some hours. During the intervals between the paroxysms there may be a dull ache or, more rarely, complete freedom from pain. Such attacks may not be repeated, but not infrequently they recur at irregular and diminishing intervals. Sometimes the pain is most intense at the same time each day, especially at night, and this intermittent character has led to the belief, in many cases erroneous, of the malarial origin of the neuralgia.

The pain shoots from a point more or less localized along the course of a nerve, though it may become more diffused. The pain may be brought on or increased by heat, cold, movement, or pressure on the part affected. Tender points (points douloureux of Valleix) corresponding to the exit of a nerve from a bony or fascial canal occur in about half the cases of long standing, and may coincide with the foci of pain. Otherwise firm pressure is not usually painful. Tenderness over the spine at the point where the affected nerve arises is present in rare cases.

Apart from the neuralgias of periodic recurrence, attacks of neuralgic pain of short duration are not uncommon in persons of neuropathic constitution. The typical protracted superficial neuralgias do not usually recur in the periodic manner characteristic of neurosal neuralgias, but from a recurrence of their underlying cause or because the neuritis still exists.

Vasomotor, trophic, and secretory disturbances may occur, but arouse the suspicion of a neuritis, which is increased if there are also muscular weakness and atrophy. Herpes zoster occurring with neuralgia indicates an underlying neuritis. Neuralgia is usually unilateral.

Diagnosis.—This depends upon the characteristic pain, which is paroxysmal and follows the course of the nerves; tender spots are often present. The only difficulty is to differentiate it from neuritis, and as these two conditions often shade into one another, it may be impossible to draw a sharp dividing line. Neuritis is generally differentiated by a more constant pain, tenderness along the nerve-trunks, muscular weakness, anesthesia, sensations of burning or cold, and trophic disturbances. Firm pressure, except on the tender spots, often relieves the pain of neuralgia but increases that of neuritis.

Treatment (See also sections on Trigeminal Neuralgia, Sciatica, etc.).—Neuralgia should not be subjected to surgical operation until medical treatment has been thoroughly tried and failed. It is of the first importance to remove the cause or causes, both predisposing and exciting (see Etiology). All extrinsic causes, such as cicatrices, tumors, foreign bodies, and inflammatory exudates, also painful affections of the brain and spinal cord, should be excluded or removed before directing treatment to the affected nerve. The system, and especially the nervous system, should be put in the best condition possible, to prevent recurrence and shorten the attack.

At the same time **symptomatic treatment** is necessary to relieve the pain and diminish the irritability and neuralgic tendency of the nerve-centers. The remedies in use for these purposes are—(1) Drugs; (2) electricity; (3) hydrotherapy; (4) counterirritation; (5) injections; (6) surgical operations.

1. Among the more important *drugs* used are quinin, aconitin, sodium salicylate, ammonium muriate, the coal-tar products, croton chloral, nitroglycerin, strychnin, arsenic, opium, iodid of potassium in large doses, and tincture of gelsemium, 1 dram every two hours pushed to its physiologic effect. The success of the drug treatment of the pain depends largely on the skill employed in finding and suitably treating the underlying and exciting causes. Gout, rheumatism, malaria, diabetes, imperfect digestion, anemia, and syphilis should be appropriately treated. After a course of specifics, tonics containing iron, quinin, arsenic, or phosphorus are most useful.

The following plans of treatment of the pain have given the best results.

Crystalline aconitin in doses of $\frac{1}{200}$ gr. until the physiologic effect is obtained, also nitroglycerin in doses of $\frac{1}{100}$ gr. every two hours, sometimes give excellent results. Strychnin hypodermatically in doses of $\frac{1}{30}$ gr., increased up to $\frac{1}{5}$ or $\frac{1}{6}$ gr. once a day, and this dose maintained for four days and then gradually reduced, has proved satisfactory in some cases where the disease is not too chronic—*i. e.*, not over four or five years in duration. This is to be combined with absolute rest and followed by iodid of potassium and iron. The use of morphin is uncertain and open to the objection of forming the habit. A similar objection applies to the coal-tar products unless used with caution. General hygienic measures should not be overlooked, the digestion and bowels should be regulated, and the patient should have abundance of food, fresh air, moderate exercise, rest, and sleep. Change to a warm equable climate may be tried during the cold damp months of the year.

Pulling out all the teeth, not uncommonly resorted to, is generally useless and unnecessary, and should be avoided except for very good reasons, as it is liable to affect the general nutrition.

2. *Electricity.*—The constant galvanic current of 35 to 50 milliamperes, with a large positive pole molded to the painful point (face, etc.) and the negative pole of double the size over the spine, affords one of the best means of palliating, if not curing, neuralgia. Each sitting should last fifteen to thirty minutes daily, and the use of electricity should be long continued. It is also very useful in the treatment of the neuritis, which is not infrequently present.

3. *Hydrotherapy,* by local and prolonged wet-packs, vapor-baths, filiform douches, prolonged warm baths, or applications of ice, etc., cures or improves a large number of cases. Dry heat in the form of hot sand- or salt-bags often ameliorates the pain.

4. *Counterirritation.*—The actual cautery gives the best results. In addition, the local application of chloroform; of stimulating liniments or ointments containing menthol, aconitin, chloroform, or iodin with belladonna or opium; of sprays of ether or ethyl chlorid, and of blisters, is often useful.

5. *Subcutaneous injections* of cocain at the focus of pain, followed by as strong a faradic current as can be borne, passed between the foramen of exit and a point one-half to one inch distant, has been found effective. The coal-tar products have been injected with good results in cases of sciatica, and osmic acid and alcohol in trigeminal neuralgia (p. 696).

6. *Surgical Treatment.*—When the above means fail, operative treatment must be resorted to. This comprises neurectomy, neurectasis or nerve-stretching, the direct injection into the nerve of osmic acid or alcohol, and the excision of painful scars combined with neurectomy. For a general description of neurectomy and neurectasis see the end of this chapter. The operations on the Gasserian ganglion and its sensory root are considered in the chapter on the Head in Vol. III.

Trigeminal Neuralgia.—Neuralgia of the fifth cranial pair, the trigeminal or trifacial nerve, is more frequent than that of any other nerve. This is partly due to the exposed position and the complexity of the connections and distributions of this nerve. Clinically it is the most important form of neuralgia, and is divided into several types. (1) Neuralgia minor, which may be named according to the branch or branches affected. (2) Reflex or symptomatic neuralgia, or visceral referred pain. (3) Neuralgia major, or "tic douloureux."

The first and second types, sometimes grouped together as the "symptomatic form" of trifacial neuralgia, have much in common and may be considered together.

Etiology.—All cases of visceral referred pain and not a few of neuralgia minor are the expression of the reaction of the nervous system to visceral irritation. This irritation is usually in the teeth (exposed or diseased pulp), but often in the eye (errors of accommodation, etc.), nose, ear, or tongue. The female sex is oftenest affected. Most cases occur in winter or spring, during the first half of life, and on the left side. As etiologic factors may be mentioned anemia, malaria, sepsis, rheumatism, exposure, traumatism, pregnancy, hysteria, and other depressing influences. Anemia has the most influence of any of the general diseases.

It is very common in the minor neuralgias of single branches to find a hereditary tendency. The first branch is particularly susceptible to neuralgia in ocular and nasal disease, malaria, or sepsis; the second and third branches in dental disorders, rheumatism, or gout.

Symptoms.—Pain is the essential feature. In neuralgia of one of the divisions the pain is usually paroxysmal; it may be intermittent or periodic. The pain corresponds to the distribution of the nerve. In reflex neuralgia or visceral referred pain the area of pain does not correspond to the distribution of a nerve, and is always accompanied by superficial tenderness of the skin and subcutaneous tissues over the same area. This tenderness is present between the attacks of pain, not usually during the paroxysm. Tenderness may sometimes be present in a case of neuralgia minor, but it then corresponds to the area of the affected nerve. In this, as in other forms of neuralgia, there may be tenderness at the points of exit of the nerve, etc. Sometimes the supra-orbital referred pain, due to the errors of refraction, is spoken of as a hêadache; at other times, as a neuralgia. In visceral referred pain and, to a less extent, in neuralgia minor, there is a tendency to pain in distant and unaffected parts. Both of these conditions are also associated with certain reflex effects. Thus an exposed tooth-pulp in the upper jaw may cause pinpoint pupils, injection of the conjunctiva, and lacrimation, in addition to the pain. All minor neuralgias are influenced by general states of the body, such as hunger, exhaustion, changes of temperature from warmth to cold, and vice versâ. Visceral referred pain is usually readily diagnosed by the superficial tenderness, the distribution of the pain and tenderness, and the presence of some source of irritation. In the early stages of a neuralgia one often cannot say whether it is a major or a minor form.

Treatment of neuralgia minor and visceral referred pains consists of the removal of the cause and the treatment of the general as well as the local condition. (See Treatment, p. 695.)

When the above means fail, neurectomy of the nerve involved, preferably by the Thiersch method (p. 756), or the injection of osmic acid or alcohol, offers the hope of a complete cure in cases of neuralgia minor (p. 695).

Tic Douloureux.—Tic douloureux is a special form of trigeminal neuralgia, to be sharply distinguished from the ordinary forms, which are mostly symptomatic. It is most severe and obstinate in its course, begins in middle or advanced life, and most often involves the second and third divisions of the nerve. The pain is fearful in its severity, rendering the disease a most terrible one, so that many patients have been led to suicide to end their agony.

Etiology.—It occurs, as a rule, in persons over forty, in fair health, who have no neurotic heredity and who are not themselves neurotic. They are, however, often the subjects of marked arteriosclerosis. After the disease has once begun, the attacks may be determined by the season of the year, exposure, overwork, or any depressing influences. During an attack the paroxysms may be brought on by the slightest thing, a breath of air, the lightest touch, talking, swallowing, etc., so that the patient dares not eat or speak. The teeth are often suspected of being the cause and are sacrificed without in any way affecting the paroxysms.

Pathology.—No pathologic lesion is constantly present. Many recent writers[5] describe it as an ascending neuritis beginning in the peripheral branches, the ganglion in time becoming the central seat of the mischief (p. 675). Keen, in two cases besides one he reported, found the disease due to the pressure of a tumor.

Symptoms.—A person in middle life and in fair health is attacked by pain in one of the branches of the trigeminus, usually the second or third, or both, more rarely the first, or all three. This pain is intense and darts along the course of the nerve from one or more points, often the upper lip, the side of the nose, or the tongue. The pain occurs in paroxysms, lightning-like in onset, which last a moment or so, disappear as suddenly as they came, and follow one another, after a comparatively free interval, for hours or days. Such attacks are very likely to recur after intervals of weeks, months, or years, at first without obvious cause, later on more frequently; some change of the weather or the season of the year may determine an attack. Each attack is liable to be more severe and more continuous, and less a series of paroxysms than the preceding ones. At first the paroxysms cease during sleep; later their continuance renders sleep impossible. According to Krause, pressure on the tender points may start a paroxysm or increase the dull sense of pain felt between the paroxysms. Tender spots are found over the points of exit on the face of the affected nerve and frequently of other nerves than those directly involved. There is no disturbance of sensation.

The disease is very persistent, and it is not rare to see patients who have suffered fifteen or twenty years. The pain is accompanied by marked vascular, trophic, and secretory disturbances, the face usually flushes, the eyes are congested, the tears and saliva flow, the nose runs, the hair and beard may change color or fall out, and there is a feeling of fullness or swelling of the affected part. The pain and accompanying symptoms are confined to one side of the face. Sometimes the muscles of the face or tongue participate in the paroxysm by spasmodic movements or a fibrillary tremor.

Treatment.—The treatment is palliative and radical. The disease is almost always mistaken at first for neuralgia minor, and many of the drugs and methods of treatment mentioned (pp. 694, 695) may give temporary relief, but, as a rule, only increasing doses of morphin have much effect. Krause forbids opium, and cocain is even worse on account of the greater danger of forming the habit.

Operative treatment is more or less radical, according to the nature of the procedure and of the neuralgia. If the disease persists after several months' treatment by medical means, operative treatment should be resorted to. Owing to the mortality of operations on the Gasserian ganglion (at least 10 per cent.) and the fact that at first we may be unable to differentiate between a major and a minor neuralgia, the peripheral operations on individual nerves should first be tried, provided all or a large number of the branches of the nerve are not involved. If the neuralgia is not of long standing and only one or possibly two branches are involved, the resection of as long a portion of the nerve as possible, or the injection of osmic acid solution or alcohol, should be tried. Neurectomy gives complete relief for a varying period. This period has in the past varied from a few months to two years, occasionally three or four years, in cases of true tic douloureux. Putnam and Waterman[6] found the average relief in forty-three such operations was ten months. A few fortunate cases of permanent cure have been recorded. The period of relief will depend upon—(1) the thoroughness of the neurectomy, and (2) the time after the onset of symptoms before the neurectomy is resorted to, *i. e.*, whether the degenerative changes have ascended above the part resected so as to involve the ganglion. It is probable that with the earlier use of the more thorough neurectomy, according to Thiersch's method (p. 756), the period of relief will be prolonged and more cases of cure recorded. According to Anschütz,[7] nearly all of twenty nerve extractions according to Thiersch in the Breslau clinic gave only a temporary relief. Rose,[8] the first to operate on the ganglion, records many successful cases of operation according to Thiersch's method which he performed instead of the more serious ganglion operation. He states that the main trunks should be attacked as they emerge from the cranium, and success depends upon the amount resected, no recurrence worthy of notice having occurred in cases operated on five and six years ago. The second and third divisions afford the best opportunities for this treatment. He adds that in well-established cases of tic douloureux all minor peripheral operations are worthless.

Angerer[9] reported Thiersch operations in twenty-six patients, of which seven were free from pain four years after operation. If the neuralgia occurs after a peripheral operation, the nerve must be removed higher up. The peripheral operations are far more curative in a case of simple trifacial neuralgia than in a true tic douloureux.

The Treatment by Osmic Acid Injections.—This was formerly employed in an injection of 1 c.c. of a 1 per cent. solution into the bony nerve canal. Good results were obtained, but almost all cases recurred after a few months. Some remained free of pain longer, even to two years.[7] According to animal experiments, other substances, such as alcohol or formalin, may act equally well or better, and Henle[10] has reported a case free of pain for eight years after an injection of a 50 per cent. solution of antipyrin. Bennett modified the technic by injecting five or ten minims of a fresh 1.5 per cent. solution of osmic acid into the nerve itself after it has been exposed. This should be done at several points about the circumference of the nerve, to make sure that all fibers are reached by the osmic acid. An additional injection may be made between the nerve and the bony canal. The contact of the solution with the soft tissues or blood causes them to blacken at once from the formation of osmium hydroxid. This does not interfere with the healing of the wound. The skin should be protected from the solution. The pain disappears within a few hours. The mode of its action is somewhat uncertain. Murphy[11] thinks that it probably acts by producing a degeneration of the nerve on the proximal side of the injection, *i. e.*, toward the ganglion, but with this there would also be a peripheral degeneration. Those who have used this method agree that it is simple, safe, effective, and worthy of more extensive use as the operative treatment to be first tried in trifacial neuralgias, especially in the very aged or feeble. The nerve may be exposed under general anesthesia or with the use of cocain.

Alcohol injections may be employed in the same way, using 1 to 1.5 c.c. of 70, 80, or 90 per cent. alcohol, with or without the addition of cocain or stovain. The method is applicable to both sensory and motor nerves. Ostwalt, Schlösser, and others have injected the nerve-trunks at the base of the skull without their exposure. As a rule, there is no sensory or motor paralysis, or only a slight and temporary one. Repeated injections may be required and recurrence may appear after several months of freedom from pain. In one-third of Ostwalt's patients pain returned in four or five months, but was relieved by subsequent injections. Two or more injections may be required before the relief from pain is complete. The final results are not yet definitely known.

Relief of trifacial neuralgia persisting at the end of four, six, and seventeen months has been reported from the resection of the superior cervical sympathetic ganglion[12]; others report unsatisfactory results from this method.[13]

While, on the one hand, peripheral operations on one or two nerves affected by trifacial neuralgia should not be undertaken until a systematic course of medical treatment has been tried, on the other hand, operation is not to be put off as a last resort until the lesion, primarily peripheral, has ascended so as to become central and no longer curable by extracranial methods. When the seat of the lesion is peripheral or uncertain, even if a lasting cure is not to be obtained, peripheral operation is indicated, for there is a considerable respite from pain and the relapse when it occurs may be milder. To obtain the best and most lasting results from peripheral operations the nerve should be removed as far centrally as possible. The branches of the fifth nerve show a very strong tendency to regeneration, leading to recurrence of the neuralgia after neurectomy, especially those branches which occupy a bony canal.

To prevent this, the nerve (infra-orbital or inferior dental) must be removed on the proximal side of the canal and the latter should be plugged at one or both ends with sterile gold- or silver-foil, dental paste, lead-shot, or silver screws. To allow this to be done the canal should not be opened up, as hereafter described in the operations on the infra-orbital nerve.

The latter nerve, after elevating the periosteum of the orbital floor, is raised up from its groove and avulsed centrally and peripherally by Thiersch's method, or a small snare is passed around it and pushed back as far as possible toward the foramen rotundum before dividing the nerve. After the nerve is extracted from the canal, the latter is then securely plugged, as above described.

After the peripheral operations the neuralgia does not always disappear at once or wholly, but only after several days of diminishing frequency or severity. The patient should be warned of this to avoid the otherwise natural disappointment.

As to the *prognosis* of the peripheral operations, many are trifling and most are safe. The area of anesthesia does not inconvenience and it becomes smaller. But the extracranial operations at the base of the skull, although not often fatal, may leave behind difficulties in the scar or in the movements of the jaw.

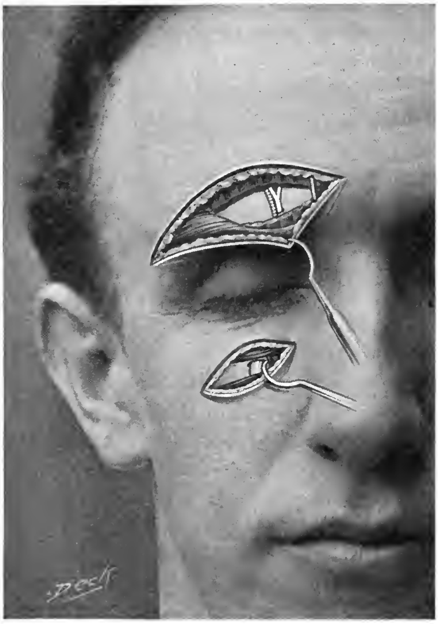


Fig. 529.—Exposure of the Inferior and Superior Orbital Nerves.

First or Ophthalmic Division of the Fifth Nerve—Supra-orbital Nerve.—This is exposed by a $1\frac{1}{4}$ inch incision along the supra-orbital margin, having the supra-orbital notch as its center. This is felt or found at the junction of the inner and middle thirds of the margin. In cutting through the skin and between the orbicularis fibers spare the small nerve branches which guide one up to the trunk. As the latter lies between layers of periosteum or between the periosteum and the roof of the orbit, the periosteum is incised along the margin (after raising the nerve branches) and bluntly separated from the orbital roof, exposing the supra-orbital and trochlear branches. These may have to be dissected out from between periosteal layers, but loosening and depressing the periosteum prevents the orbital fat getting into the wound and obscuring free vision. The frontal branch can be reached central to its division into the supra-orbital and supratrochlear branches. The division or avulsion of the frontal trunk insures against overlooking any small branches, as may occur when the latter are separately divided. The wound may be closed by suture, and the scar, being among the hairs of the eyebrow, is not noticeable. Through this same incision, or one a little more internal, and by the same method, the nasal branch may be reached at the anterior ethmoidal foramen, about two centimeters from the orbital margin. This branch, or the lateral part of it, may be reached by an incision over the pyriform aperture between the nasal bone and the triangular cartilage.

The Second or Maxillary Division of the Fifth Nerve—Infra-orbital Nerve.—This, the most frequently affected nerve, may be reached at the infra-orbital foramen, one centimeter below the lower orbital margin, at the upper end of the canine fossa, and vertically in line with the supra-orbital notch. The four-centimeter-long incision may be carried along one-half centimeter below the infra-orbital margin, outward and downward to the postero-inferior border of the malar bone. By this incision the branches of the facial nerve to the facial muscles below and to the orbicularis palpebrarum above are avoided. The origins of the zygomaticus major and levator labii superioris are divided and the incision carried to the bone exposing the foramen, whose upper and outer margin is the sharpest and best felt.

To avoid the scar of the incision on the face the foramen may be reached by an incision through the mucous membrane and periosteum along the line of reflection of the former from the upper lip to the canine fossa. Then the soft parts with the periosteum are separated from the bone up to the foramen. In this procedure it is well to remember that the foramen lies in a vertical line drawn through the interval between the two bicuspid teeth or through the second bicuspid.

When the nerve is exposed at the foramen, it should be followed back at least as far as the sphenomaxillary fissure. This may be done with or without opening the antrum. The method without opening the antrum is preferable, as the wound is more sure to heal by primary union and without deformity. For this purpose the external incision is made use of, and the periosteum, after division along the infra-orbital margin, is separated downward to the foramen and backward along the floor of the orbit to the entrance of the canal. The thicker anterior end of the roof of the canal involving the orbital margin is then removed with the chisel, while the posterior thin part, through which the nerve is seen as a whitish band, may be broken with thumb forceps. The canal and groove run nearly directly backward. The nerve is now separated from the accompanying artery, which lies below and internally, seized with forceps, and, while the periosteum and overlying orbital contents are raised by a retractor, isolated back into the fissure. The nerve may here be excised or preferably avulsed by Thiersch's method, both centrally and peripherally.

Through either incision the antrum may be opened, just below the foramen, by a half-inch trephine or burr or a chisel. The floor of the canal and groove is then opened up by the chisel or strong scissors and the nerve is isolated and followed back to the sphenomaxillary fissure. The opening of the antrum adds to the danger of infection through the nose.

By either method it is often possible to divide the nerve behind the posterior dental branch, which is usually given off in the sphenomaxillary fissure. To make sure of including the posterior dental branches and to include the sphenopalatine branches to Meckel's ganglion and the orbital branch, and in order to obtain the most lasting results from the operation, it is necessary to resect the nerve at the foramen rotundum, in which case the only branch that escapes is the recurrent branch to the dura. This operation is also called for in case of recurrence after a more peripheral operation.

Exposure and Division of the Superior Maxillary Nerve at the Foramen Rotundum.—*Carnochan's method* is only a continuation of the last-described method through the antrum. To the incision below the infra-orbital margin may be added one running down the groove between the cheek and the nose and the flap reflected downward. The antrum is opened by a half-inch trephine just below the foramen, the canal chiselled out, the nerve followed back, and the posterior wall of the antrum opened just below the course of the nerve by a quarter-inch trephine, thus exposing the sphenomaxillary fossa. The nerve is now brought into the posterior trephine opening and bluntly followed back through the sphenomaxillary fossa to the foramen rotundum, where it is severed with curved scissors, twisted, or torn off. The sphenopalatine branches, passing down to the ganglion, may require separate division. The length of the nerve from the infra-orbital to the round foramen is about one and three-quarter inches. Bleeding may be controlled by pressure. A head-light is very serviceable.

The other methods, of which there are many modifications, consist in the temporary resection of part of the zygoma and malar bone, approaching the sphenomaxillary fossa from the outside. The incision in most of these methods involves division of the fibers of the facial nerve which supply the orbicularis palpebrarum muscle. This should, if possible, be avoided, for it results in inability to close the eye, favors conjunctival inflammation and lacrymation, and in case the extirpation of the Gasserian ganglion becomes necessary, on account of recurrence, it endangers the eye.

The most commonly described *Lücke-Lossen-Braun operation* presents this drawback in the angular incision which, commencing one centimeter above the outer canthus of the eye and two to three millimeters from the external orbital margin, passes downward and forward to the region of the third upper molar and from the same starting-point runs backward along the upper margin of the zygomatic arch. The zygomatic arch is turned down after it has been divided in front and behind and the temporal fascia incised along its upper border. With a blunt retractor the temporal muscle, as well as the fat and venous plexus of the sphenomaxillary fossa, are drawn back, exposing the sphenomaxillary fissure and the infra-orbital nerve.

Kocher's operation avoids the injury of the facial fibers. The incision is the same as that for exposure of the infra-orbital nerve at the infra-orbital foramen, only prolonged further outward and downward over the lower part of the body of the malar bone to the zygoma. Stenson's duct lies below the incision. The periosteum is divided and reflected upward to the orbit, and downward, exposing the infra-orbital nerve at the foramen. At the outer end of the incision the zygomatic muscles are detached and then the anterior fibers of the masseter are separated from the lower and inner part of the malar bone. Both surfaces of the malar are bared with a periosteal elevator, as also the anterior surface of the malar process of the maxilla up to the foramen and the outer wall and floor of the orbit back to the sphenomaxillary fissure. The chisel, inclined outward and downward a little below and parallel with the malomaxillary suture, is driven backward and outward into the anterior end of the sphenomaxillary fissure so as to remove the roof of the infra-orbital canal. This opens the antrum at its upper and outer part. The incision is then retracted upward so as to expose the frontomalar suture, and from here the chisel is carried downward, inward, and backward toward the posterior part of the sphenomaxillary fissure through the orbital plate of the sphenoid. The Gigli saw may replace the chisel in the division of bone, but the chisel is preferable. After division of the zygoma the malar bone is dislocated outward and upward by a strong sharp hook, and the orbital contents, protected by periosteum, are raised by a blunt retractor. The infra-orbital nerve can then be followed back through its opened canal to the foramen rotundum, where it is severed or wrenched out (Thiersch). The artery accompanying the nerve may be ligated or avoided. The malar bone is then pressed back into position and does not usually require fixation sutures.

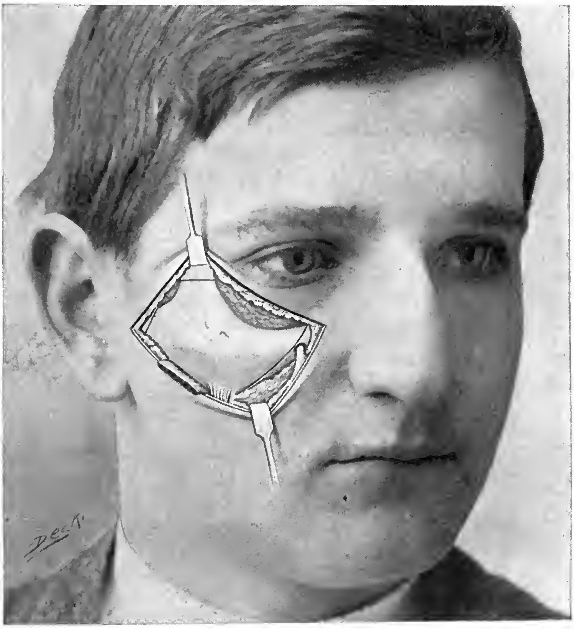


Fig. 530.—Kocher's Method. Exposure of Superior Maxillary Nerve.

The superior maxillary nerve, as well as the inferior, may be exposed and severed at the exit from the skull by Kocher's incision for the third division of the trifacial. The excision of the superior maxillary nerve at the foramen rotundum has the disadvantage of paralyzing the Vidian nerve, and thereby the branches from the facial to the muscles of the palate (p. 702).

The Third or Mandibular Division of the Fifth Nerve.—The mental nerve can easily be reached at its foramen below the second bicuspid by an incision through the fold of mucous membrane from the lip to the gums.

But on account of speedy recurrence operation at this point is not advisable, even when the neuralgia is confined to the mental nerve, and generally it involves the dental branches. Even by the Thiersch method of avulsion the nerve usually tears out just behind the foramen and the dental branches escape.

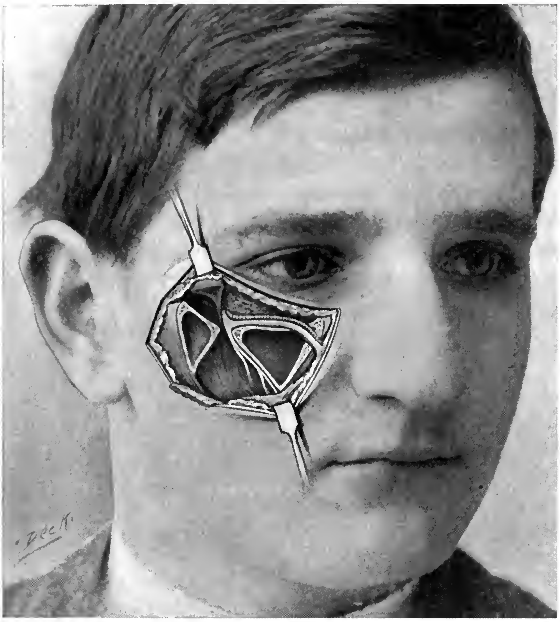


Fig. 531.—Kocher's Method. Exposure of Superior Maxillary Nerve, No. 2.

The **inferior dental nerve** enters its canal midway between the anterior and posterior borders and the lower border and sigmoid notch of the ramus, and just behind the prominent lingula. It may be reached for neurectomy or avulsion in many ways:

(*a*) *Perforating the Jaw Opposite the Canal.*—The three-centimeter-long vertical incision is objectionable because of the danger to the branches of the facial nerve to the chin and lower lip. A three-centimeter-long horizon-

Fig. 532.—Exposure of Inferior Dental Nerve.

tal incision may be made down to the masseter over the position of the canal, the edges retracted upward and downward, the masseter split in line with its fibers, and a piece of bone removed by chisel or trephine to expose the nerve. Again, after making a curved incision around the angle of the jaw, the masseter may be detached from the jaw and retracted upward until the center of the ramus is reached, when the trephine or chisel is applied. The artery, which lies behind the nerve, can usually be bluntly isolated and avoided.

(*b*) *Methods Without Perforating the Bone.*—Through an incision along the lower part of the posterior border for 1.5 cm. and then forward along its inferior border a variable distance the parotid gland is exposed and retracted backward and the periosteum is incised along the exposed part of the borders of the jaw. Then the internal pterygoid muscle with the periosteum is raised from the bone by an elevator, aided, if necessary, by the knife or scissors, until the lingula (or spine of Spix) is reached and felt with the finger. The internal pterygoid is retracted inward and the nerve is then hooked down with a small blunt hook. If necessary, the lingual nerve can be reached through the same incision by seizing the inferior dental nerve with a clamp and pulling it downward until the point is reached where the lingual branches off from the common trunk. The nerve or nerves may be resected for the space of 2 to 3 cm., or they may be avulsed. To facilitate the above method the angle may be partly sawn through from the inner side at a distance of 2 cm. on either border and then broken outward by blunt forceps, to be replaced at the end of the operation.

(*c*) *Intrabuccal Method.*—The anterior border of the coronoid process can be readily felt behind the alveolar processes when the mouth is held widely open with a mouth-gag. An incision is made along this border through the mucous membrane and down to the bone. The soft parts are separated from the bone in a backward direction until the lingula is felt. The nerve is then hooked forward from behind it with a blunt hook. The disadvantages of this method are that only a small portion of nerve can be removed and a wound is left that may become infected from the mouth.

The *lingual nerve* may be readily exposed in the floor of the mouth by pulling the tongue to the opposite side, when the nerve forms a ridge in the floor of the mouth between the tongue and the jaw. Incision through the mucosa over this ridge, opposite the back molars and not too near the tongue, exposes the nerve for resection. If this procedure is prevented by the size and position of the mass, in case of epithelioma of the tongue, the nerve may be exposed with the inferior dental or in the submaxillary triangle after raising the submaxillary gland. The *auriculotemporal nerve* is exposed peripherally by a vertical incision over the root of the zygoma where the nerve lies behind and under cover of the temporal artery.

The *inferior dental and lingual nerves* may be exposed and resected at the base of the skull, *at the foramen ovale,* by the following procedure. A flap of skin and subcutaneous tissue is marked out by an incision from the middle of the zygoma backward and a little downward to a little below the tragus, thence downward along the posterior border of the ramus to the angle, and then forward for 2 cm. along the lower border. The flap reflected forward leaves the facial nerve branches beneath it. After incising down to bone below and parallel with Stenson's duct one-half inch below the sigmoid notch the bone is denuded by an elevator for an inch below the notch, and a three-quarter inch button of bone removed by a trephine, leaving not more than one-quarter of an inch between it and the notch. This bridge of bone is removed with the rongeur, thus deepening the sigmoid notch and leaving the condyle and coronoid process connected with the rest of the bone. Retracting the tendon of the temporal muscle forward, and removing with the forceps any fat overlying

FIG. 533.—KOCHER'S METHOD, INFERIOR MAXILLARY NERVE, NO. 1.

the external pterygoid muscle, the latter is seen and retracted upward, thus exposing the inferior dental and lingual nerves which come out from under it and rest on the internal pterygoid muscle beneath it. The nerves, pulled downward, are traced up to the foramen ovale and divided, or they may be avulsed. Krause, removing these two nerves in the latter manner, found some of the Gasserian ganglion connected with the stump of the nerve.

There are many other methods of exposing the inferior maxillary nerve at the foramen ovale, such as those of Krönlein, Mikulicz, Salzer, Kocher, etc. Of these, only those are to be employed which avoid, as far as possible, injury to branches of the facial nerve innervating the orbicularis palpebrarum.

It will suffice to describe two methods: one from above, with temporary resection of the zygoma (Kocher's); the other from below, retrobuccal, with resection of the coronoid process (Krönlein); or of the mandible (Mikulicz).

Kocher's Method.—The incision commences just behind the frontal process of the malar, and is carried obliquely downward and backward, through the temporal fascia, to the posterior extremity of the zygomatic arch, and thence upward and backward, down to the bone, in front of the ear, dividing the temporal vessels. The only branch of the facial nerve divided is that to the occipitofrontalis. The lower edge of the incision is retracted downward, exposing the zygomatic arch, which is divided posteriorly close to its root and anteriorly just behind the frontal process of the malar and then retracted strongly downward. The underlying fat is removed and the temporal muscle, separated bluntly from the skull along its postero-inferior aspect, is drawn well forward. After dividing the periosteum along the pterygoid ridge from the anterior root of the zygoma forward, the soft parts with the periosteum are elevated from the bone in a mesial direction until the base of the pterygoid process is reached. The foramen ovale lies just behind and slightly lateral to the posterior border of this plate, and about 3 cm. mesial to the anterior root of the zygoma, with the middle meningeal artery just behind it. The internal maxillary artery lies in the soft parts retracted downward, with the periosteum covering and protecting them. The trunk of the nerve emerging at the fora-

FIG. 534.—KOCHER'S METHOD, INFERIOR MAXILLARY NERVE, NO. 2.

men ovale, can be seized with a small blunt hook, drawn into view, and cut, or seized with forceps and pulled out. The zygomatic arch is replaced and fastened with periosteal sutures of chromic catgut. The wound is closed with or without drainage.

Krönlein's Retrobuccal Method.—The cheek is split from one centimeter behind the angle of the mouth to one centimeter in front of the lobule of the ear through the subcutaneous fat down to the buccinator muscle. The anterior two-thirds of the masseter are divided in the same line without wounding the parotid gland or duct, which latter lies above it. This incision parallels very nearly the facial nerve branches, though one cannot be

FIG. 535.—SITES OF THE BONE INCISION. SECOND AND THIRD DIVISION OF THE FIFTH NERVE. KRÖNLEIN'S TEMPORAL METHOD, NO. 1.

certain to avoid them all. The coronoid process, freed by an elevator from the attachment of the masseter, is cut through its base obliquely forward and downward and retracted upward together with the tendon of the temporal muscle. After removing the underlying fatty layer by blunt dissection, the nerves are exposed on the lateral aspect of the internal pterygoid and followed up to the foramen ovale. To allow this it is necessary to retract the external pterygoid strongly upward, or, in addition, to tear some of the fibers which run over the nerve. It may be advantageous to tie the internal maxillary artery.

In closing the wound the coronoid process is sutured periosteally and a small drain left. Stiffness of the jaw may follow the operation, due to the injury of the temporal muscle and the coronoid process. This may be largely avoided by removing entirely the coronoid process. In this connection it is to be remembered that the operation, by dividing the motor nerves of the muscles of mastication, permanently paralyzes them, so that the function of the temporal muscle in any case is lost.

Through the anterior part of the incision, *i. e.*, in front of the anterior border of the masseter, the *buccal nerve* may be exposed, after removing or retracting Bichat's lobule of fat, at the anterior border of the temporal tendon on the fibers of the buccinator muscle. Mikulicz has modified Krönlein's method by temporarily dividing the jaw in front of the ramus

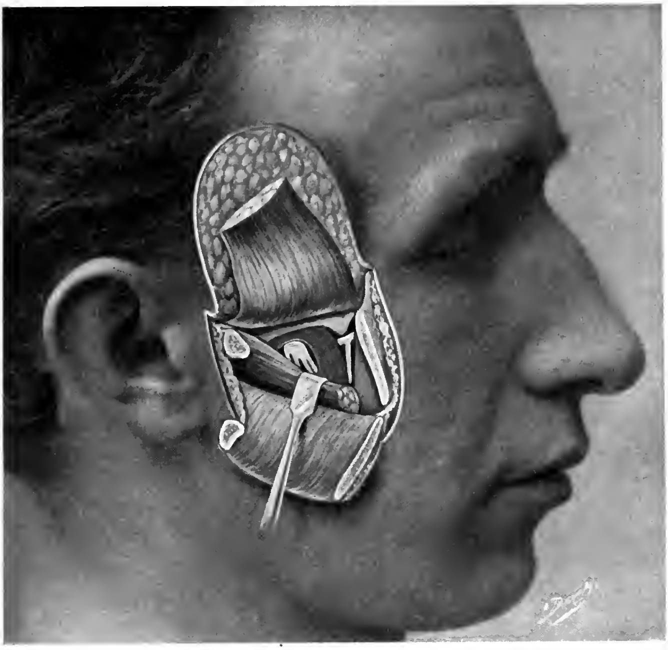


FIG. 536.—SECOND AND THIRD DIVISION OF THE FIFTH NERVE. KRÖNLEIN'S TEMPORAL METHOD, NO. 2.

and turning up the entire ramus, instead of resecting the coronoid process, but the operation is then rendered more serious.

The second and third divisions may be resected together at the base of the skull according to *Krönlein's temporal method* (Figs. 535 and 536). The skin flap, which reaches down to the level of Stenson's duct, is retracted upward. After division of the zygoma (Fig. 535) and of the temporal fascia along its upper border, it is retracted downward with the masseter muscle. The coronoid process is then divided at its base and extirpated, and the temporal muscle retracted upward. After doubly ligating and dividing the internal maxillary artery the upper head of the external pterygoid muscle is bluntly separated from beneath the great wing of the sphenoid. The external pterygoid plate is thus reached and serves as a guide, as in Kocher's method. The second division is then reached in the sphenomaxillary fissure and fossa by blunt dissection. At the close the zygoma is sutured in position. The upper branches of the facial are divided in this operation.

Sciatica.—This affection of the sciatic nerve is one of the commoner forms of localized nerve pain. Its common occurrence is due in part to the position of the nerve, in which it is exposed to injury, etc., both within and without the pelvis.

Etiology.—Most cases of sciatica are now known to be due to a neuritis. Such cases occur mostly in middle life, more often in men than in women, and in the autumn and winter seasons. As predisposing causes may be mentioned constitutional affections which impair the general nutrition and vital tone or the quality of the blood; gout; diabetes; digestive defects, etc. Exciting causes are exposure to cold, trauma, overstrain, pressure or neighboring inflammation, and irritation within the pelvis. In some cases it is more of a true neuralgia and occurs in younger subjects having a neurotic constitution.

Pathology.—This, in the majority of cases, is a chronic perineuritis, usually localized at the sciatic notch or in the middle of the thigh. Pressure upon or adhesions of the nerve within or at its exit from the pelvis are not uncommonly present. There is often a venous hyperemia of the nerve-sheath or a localized thickening of it.

Symptoms.—The pain, which is nearly continuous, with occasional sharp paroxysms, extends along the course of the nerve, but generally it is centered in certain regions, especially the back of the thigh, less often the popliteal space, the back of the calf, or the sciatic notch. It may begin in or extend into the lumbar region, resembling lumbago. The pain is often intense and is aggravated by motion. In addition the course of the nerve presents certain tender points which may be found at the sciatic notch, the middle of the thigh, the back of the knee, below the head of the fibula, behind the outer malleolus, etc. The onset of the pain may be sudden or gradual. When neuritis is present, there may occur muscular weakness and atrophy, numbness, tingling, a feeling of coldness, trophic disturbances, herpes, etc. Loss of knee-jerk is observed in some cases. Flexing the limb at the hip with the knee extended causes a sharp pain in the sciatic notch, which is due to traction on the nerve and is diagnostic.

To relax the nerve the pelvis is tilted up on the sound side, and the trunk bent convexly toward the affected side. If this position remains long uncorrected, it sometimes leads to a characteristic deformity (sciatic scoliosis).

Prognosis.—This depends upon the cause as to the duration. Most cases recover in from two to six months; purely neuralgic cases are of shorter duration, and some severe cases may last much longer. Relapses are not common; recurrences are seen.

Diagnosis.—A double sciatica almost always indicates pressure within the pelvis or a lesion within the vertebral canal. In osteo-arthritis of the spine the pain is often distributed in patches. Neuralgic and neuritic sciatica may be differentiated by the neuritic symptoms of the latter.

Treatment.—The first and most important indication is rest in bed with some form of long hip splint. Any possible predisposing or exciting cause should be removed or treated. Then the local application of heat or cold, counterirritation by the actual cautery or blisters, massage, and gymnastics should be employed. Turpentine (15 drops thrice daily), quinin, sodium salicylate, or potassium iodid in large doses may be given in the early stages with some hope of relief. The bowels should be kept carefully open, and any rheumatic or gouty condition or any digestive disturbances should be thoroughly treated. Local remedies, such as menthol, guaiacol, betulol, and the like, sometimes prove useful.

On the other hand, some advise and get good results from the earliest possible use of massage and active and passive movements, at first under anesthesia, if necessary, as stretching the nerve causes great pain. The patient is made to walk as much as possible. Baths and electricity may aid the cure. Even chronic cases may be successfully treated in this way.

Later, as the condition becomes more chronic, the galvanic current, applied with large electrodes, the positive over the calf or foot the negative over the sciatic notch, may be serviceable. Deep massage or pressure[15] on the nerve to remove the inflammatory exudate may be useful, even if painful. Internally nitroglycerin, salophen, antipyrin, and other coal-tar products may give relief.

The number of plans of treatment recommended for sciatica that resists the above treatment indicates that no one is to be always relied upon, though good results are obtained by all. The following forms of local treatment may prove curative.

Cramer[16] puts the thigh in a water-glass spica for four weeks in a position of slight flexion, outward rotation, and abduction, in which position the sciatic nerve is relieved of both pressure and traction. He reports good results.

Deep injections into or around the nerve have proved effective. Antipyrin has given good results; so has glycerophosphate of soda,[17] so that it is not unlikely that it is the bulk of the fluid, rather than its nature, which is curative. Thus Lange,[18] who reports five cures from the injection of 70 to 100 c.c. of a β-eucain Schleich solution in close contact with the nerve at the foramen, attributes the result to the distention and tearing effect of the injected mass of isotonic fluid.

Cocain has been employed with good results also by lumbar puncture, sometimes in quantities sufficient to produce anesthesia (1–2 cg.), sometimes in smaller doses (5 mg.), with or without withdrawing 3 c.c. of cerebrospinal fluid.

The commonest method of surgical treatment of obstinate sciatica is that by *nerve-stretching* (neurectasis). This may be done by the open (wet) method or without incision (dry stretching). Nerve-stretching in sciatica gives promise of success only in cases due to neuritis. Dry or bloodless stretching is accomplished by flexion at the hip-joint with the knee extended. Good results are obtained and have been reported,[20] but it has not many supporters because it is uncertain, haphazard, and may not stretch the nerve enough, and other structures, like the hamstring muscles, too much.

Wet stretching is more to be depended on, though this too not infrequently fails and has to be repeated. Schede reported 21 cures (16 lasting) in 24 cases, but his statistics are unusually favorable. Under anesthesia the nerve is exposed just below the gluteus maximus muscle, where it lies beneath the skin and deep fascia in a line from the middle of the popliteal space to the junction of the middle and inner thirds of the line from the ischial tuberosity to the outer border of the great trochanter. Deepening the incision, whose center is where the first line crosses the lower border of the gluteus maximus, this muscle and the biceps are exposed. The latter is retracted outward, the former upward, and the nerve is exposed at a deeper level above the point where it passes beneath the biceps muscle.

Fig. 537.—Exposure of Great Sciatic Nerve.

Traction should be made on the nerve in both a central and a peripheral direction. Although Trombetta found that it required a weight of 183 pounds to break the sciatic nerve, a far less force applied centrally may damage its connections with the cord or even tear it away from it. Hence care should be exercised in not pulling too hard on the central end. Apart from the effect on the nerve itself and its vascular supply, the stretching tends to break up adhesions about the nerve-sheath. These are most likely to be found at the sciatic foramen or in the pelvis.

To treat the latter conditions directly, V. Baracz[21] exposes the nerve at the foramen and by blunt dissection with the finger loosens it from adhesions about or above the notch. Bardenheuer[22] goes still further and by partial, or in case of disease complete, resection of the sacro-iliac joint enlarges the foramen and loosens the first or superior sacral root, which is the one most affected in sciatica. This is a too severe procedure unless other less severe operative methods have been tried and failed.

TUMORS OF NERVES.

These are not very common. They occur in the form of true neuromata, the various manifestations of neurofibromatosis, and, less often, as malignant growths, either primary (rare), metastatic, or degenerative.

True neuromata are very rare and may be due to an increase of medullated, more often of non-medullated, fibers. They are usually single, but occur rarely as multiple growths, and may then be very numerous—1000 in one case (Gowers). Multiple nerve tumors are, however, generally neurofibromata. True neuromata are usually small, ranging from 1 to 6 cm. in diameter.

The **amputation neuroma** is a neurofibroma. It occurs wherever a nerve is divided and irritated by the scar tissue embedding it, and has been less frequently observed since the use of aseptic wound treatment. Where the nerve is simply cut in its continuity, it occurs mostly on the central end, rarely on the distal end. It presents a bulbous enlargement at the end of the nerve, due to the formation of small medullated fibers, produced by irritated neuroblasts, and of new connective tissue (p. 684). There may rarely be an enlargement of the nerve above the bulbous end. This may account for the recurrence not infrequently observed after removal. Hence in their removal in amputation stumps, on account of pain which interferes with the wearing of an artificial limb, the nerve should be cut as high as possible and above any visible enlargement. To prevent their formation the nerves should be cut short at the time of amputation. When they occur on a divided nerve, they are useful to show the position of the nerve stump. They require removal in secondary nerve suture.

Other enlargements may occur on nerves, such as lepra nodules, gummata, tuberculous nodules, sarcomata, etc. Adjacent tumors of any kind, especially malignant growths, may involve the nerves by extension of their growth.

Neurofibromatosis (*cf.* p. 682) includes the following conditions: (1) Neurofibromata, usually multiple; (2) multiple fibromata of the skin—fibromata mollusca; (3) plexiform neuromata; (4) tubercula dolorosa; (5) certain forms of elephantiasis, and certain pigment nævi.

1. *Neurofibromata* occur as single or multiple tumors on one or more cerebrospinal or sympathetic nerve-trunks, except the optic and olfactory. Sometimes there is but one at other times several on a given nerve, and again there may be very numerous growths throughout the body, as in the case described by Prudden, where there were over 1000.

Neurofibromata usually originate from the endoneurium, less often from the perineurium, and rarely from the epineurium, hence they are usually situated centrally (endoneurial variety), less often peripherally (epineurial variety). They are spindle shaped or round, hard or soft, and vary in size from a bead to a grape-fruit. They are not commonly found in the hands or feet, although Keen has operated on and reported such a case.[24] Although generally slowly growing benign tumors, they not infrequently exhibit a myxomatous, cystic, or fatty degeneration, and less commonly they take on a sarcomatous growth.

2. Besides the neurofibromata connected with nerve-trunks, neurofibromata of the terminal filaments of the cutaneous nerves occur, as demonstrated by Recklinghausen. These constitute the *multiple fibromata of the skin*—the so-called *fibromata mollusca.*

3. The *plexiform neuroma,* according to Bruns, is the result of massive fibromatous thickening of the nerves of a circumscribed area, a cylindric neurofibroma, and differs only in form from the preceding two varieties. The thickened nerves are also greatly elongated so as to be in serpentine or plexiform folds. The nerve-fibers themselves are usually degenerated. The tumors are found most often in the temporal region or on the side of the face and neck, but they may affect almost any part and have even been described on the tongue.[25] They may recur even after careful removal. In a more diffuse form they produce the elephantiasis neuromatodes.

4. *Tubercula dolorosa* are small, very painful cutaneous nodules which apparently originate from the sensory nerve filaments of the skin.

Several of these conditions may occur in a single case, giving rise to the condition known as neurofibromatosis, presenting tumors both of the nerves and skin, with or without pigment patches. A case of unilateral distribution of this condition has been reported.[26]

Etiology.—All forms of neurofibromatosis are sometimes hereditary, and still more often congenital. Heredity through three generations has been observed by Bruns,[27] Menke,[28] and others. Plexiform neuromata are almost always congenital. Traumatism may be an etiologic factor, as instanced in amputation neuromata. They have been observed following arsenic poisoning and some infectious diseases. Otherwise we know little of the etiology of these tumors.

Symptoms.—Clinically, this condition may be divided into cases with and cases without symptoms. In the latter case the tumors may not be discovered until the autopsy.

Paresthesia, neuralgic pains, paresis, contractions, and reflex spasm are among the symptoms observed in different cases. Fortunately, multiple neurofibromata are usually painless. The cases with a solitary tumor or only a few tumors and those with several very small nodules (tubercula dolorosa) are those most likely to give rise to symptoms. Sarcomatous changes in a previously benign case without symptoms may cause the onset of symptoms, probably from the pressure of the enlarging tumor.

The danger of a benign neurofibroma becoming malignant (sarcomatous) is a real, and not an imaginary, one. Some time ago Garré[29] collected seventeen cases of sarcomatous degeneration in congenital neuromata. Such cases show a strong tendency to recurrence and metastasis. Apart from this danger and the rare one of a tumor growing within the spinal canal or skull, the prognosis is good. Neurofibromata may recur after removal.

Treatment.—The cases without symptoms require no treatment except that plexiform neuromata may be removed for cosmetic purposes or to avoid interference with function, present or threatened, when they occur on the extremities.

When the tumors cause symptoms, they should be removed. Care should be taken to avoid injury to the nerve. In the central or endoneurial growths, the incision should exactly parallel the course of the fibers, if possible passing along the bands of fibrous tissue which separate the fasciculi of the nerve. When the tumors are reached they are, as a rule, readily shelled out. This can usually be done with but little injury to the nerve and its function.

WOUNDS AND INJURIES OF NERVES.

These include incised and punctured wounds, laceration, contusion, and compression. The simplest and best known form of nerve injury is the incised wound or nerve section, complete or incomplete. This is most common in the upper extremity, and especially in the forearm, from glass cuts and other incised wounds, usually in connection with the wounds of tendons and blood-vessels. If complete, the ends usually separate by a considerable interval, so that the conditions are not favorable for union without suture.

Punctured wounds are more apt to involve incomplete section of a nerve, in which case the ends are not separated and union is more likely to be rapid and perfect. Apart from this fact, and the greater danger of infection in some cases unless they are freely opened, these wounds differ but little from incised wounds. Bullet wounds of nerves are of this variety and, while many cause a complete or partial division of the nerve, in others the symptoms are due to a contusion of the nerve.

Laceration of a nerve, like an incised wound, may be partial or complete. The nerve-fibers are torn instead of cut, and give way at somewhat different levels. Laceration is due to a sudden severe stretching. Such injuries are seen in the brachial plexus when the neck and shoulder are forced apart. If the laceration is complete, the ends may be pulled apart so as to be separated by a wide interval: if incomplete, the remaining fibers may be so damaged by stretching as to undergo degeneration, or they may in part recover function, but in the latter two cases the ends are in closer relation to one another. In laceration the sheath gives way first, in part at least, before the fibers yield. (See Degeneration and Regeneration, p. 688.)

The **symptoms** of these forms of wounds of nerves are essentially the same and depend upon whether the nerve is completely or partially divided. In this connection we should bear in mind that a peripheral or mixed nerve contains motor, sensory, vasomotor, and trophic fibers.

Symptoms of Complete Division of a Mixed Nerve-trunk.—The pain is no greater than that due to a skin wound, nor is the shock great in the case of a small nerve at the periphery. The division of the large nerve-trunks in a high amputation of a limb is one of the elements of the shock of the operation, which can be avoided by "blocking" with cocain.[30] The muscular power in the group of muscles supplied by the nerve is lost absolutely and at once, and remains lost until union and regeneration of the nerve have taken place. The function of the paralyzed muscles may to a certain slight extent be supplied by neighboring muscles. The muscles rapidly atrophy and deformities are common. The latter occur when the origin and insertion of the paralyzed muscles are allowed to remain approximated during their atrophy. They may more rarely be due to the unopposed action of the unaffected muscles. Hence the importance of careful attention to the position of the paralyzed parts. Occasionally the division of a nerve, even a small nerve, may be followed by a reflex paralysis of one or both extremities of the opposite side. Rarely the whole body is thus paralyzed for a time, the result of exhaustion of the nerve-centers, according to Mitchell, Morehouse, and Keen.[32a]

The *electric irritability* of the divided nerve and its muscles diminishes, for as the nerve degenerates it requires an increasingly stronger current and one of longer duration to stimulate it. In man the faradic excitability disappears rapidly, *i. e.*, in from three to eight days. The galvanic irritability also diminishes rapidly, so that in two to three weeks only slight fibrillary contractions occur, and in three to six weeks they disappear. This loss of reaction to weak, then to rapid and short, currents, and finally to the galvanic current, forms a part of the reaction of degeneration, known as the *quantitative change* in electric irritability. Whereas normally the contraction due to closure of the negative pole is stronger and more readily produced than that due to closure of the positive pole, the reverse is true or the two are equal, a week or ten days after nerve section. This is expressed by the formula ACC or KCC and is called the *qualitative change* in the irritability of the muscle. This reaction is of great diagnostic value and reliability, but requires care in testing for it, and is obtained only by placing the active electrode over the muscle. The *modal change* in irritability is the change in the contraction, due to either the galvanic or faradic current, from a sharp jerky one to a sluggish almost tetanic one.

If the divided nerve does not unite, the electric excitability does not return. After union of a divided nerve voluntary power returns from a month to a year or more before electric excitability, so that mere absence of the latter is not of itself a sufficient ground for a bad prognosis. The faradic and galvanic irritability may return at the same time or the faradic first. The galvanic irritability when it returns is usually normal; rarely it has shown the reaction of degeneration.

Sensation is affected in various ways. The senses of touch, temperature, and pain are lost in varying degrees. In addition paresthesias may be present, such as pricking, numbness, and tingling. Both the sense of temperature and that of pain are lost over the same area as, and in the same proportion with, the sense of touch, but they may also be lost where anesthesia is not complete. Anesthesia is the most obvious symptom to the patient. As a rule, it is complete, but not infrequently the terminal branches are not completely anesthetic, or the area of absolute anesthesia may be quite small. This is explained by the fact that the areas of distribution of cutaneous nerves overlap one another or by the supposition of nerve anastomosis producing so-called "supplementary sensation." The latter is very imperfect at best, but by use it becomes more developed in time, though occasionally it may be only temporary (Létiévant). The amount of this supplementary sensation varies with the nerve divided. After primary suture of a nerve surgeons may be misled by this supplementary sensation to infer immediate union of the nerve-fibers. Return of sensation alone is not sufficient proof of new nerve formation, but when, in addition, trophic lesions subside and atrophied muscles regain their bulk and contractility nerve union is proved. *Hyperesthesia*, as a rule, is only present in incomplete section and in conjunction with neuritis.

Trophic changes of various kinds, first described by Mitchell, Morehouse, and Keen,[32b] not infrequently occur after complete section of a nerve-trunk, but many of them are exceptional, not the invariable consequence of the lesion. With the exception of simple atrophy of muscles we see trophic changes only when we have an irritative lesion of a nerve-trunk, not when the lesion is absolutely aseptic. The *skin*, especially in the terminal distribution of the severed nerve, may become smooth, shiny, red, hairless, and often painful on motion of the part. This is known as "glossy skin." An herpetic eruption, or larger bullæ in the early stages, painless subcuticular abscesses (subcuticular whitlow of Hutchinson), or ulcers may appear, and the latter may go on to the destruction of the tip of the finger. The *nails* may become more curved (*i. e.*, clubbed), dry, scaly, ridged, and furrowed transversely and striated longitudinally. This change is found not long after the injury, not in old cases. *Sweating* is wanting, but in some cases, with neuritis, it may be excessive and have an acid odor. The *temperature* is increased at first, but in the course of a few weeks it is diminished and the parts become cold and livid. The atrophy of the muscles is a true trophic degeneration and not simply due to disuse.

One to six weeks after the injury the *joints* are apt to become somewhat stiff, and may go on to fibrous ankylosis unless manipulated. The joint lesions are often painless, but in other cases there is a painful, tender swelling of the joints.

The end-bulbs, which may form on the central end, rarely on the distal end also, can often be felt through the skin at a little distance from the level of the wound. After division the central stump may retract some distance from the line of section.

In *partial section* of a nerve-trunk the trophic lesions are less marked and, as a rule, absent; the paralysis and loss of sensation are incomplete. Experimentally hemisection of the sciatic in animals has little effect, as it only divides about one-half of the fibers of any one nerve branch, for the fibers of the latter are scattered through the trunk until just above the branch. Stimulation above and below the point of section produces the same result. The inference is made that the quantity of nervous influence carried by any branch to the muscles can be considerably reduced without serious disturbance to the muscular system.[31] In man the motor and sensory symptoms of partial nerve section are more noticeable than in animals experimented on, and their degree depends upon the extent of the section. As the divided ends are held in close apposition, union is as a rule rapid and restoration of function excellent.

The **diagnosis** of the injury and the particular nerve or nerves involved is comparatively easy and depends upon the history of the injury, the exploration of the wound, if an open one, and a consideration of the symptoms and the area involved.

Treatment.—Although performed by Amemann in 1826, Flourens in 1828, and later several times by Dupuytren, nerve suture was first practised on a definite physiologic basis by Laugier in 1864, when he sutured the ends of a recently divided median nerve. Whichever view of the regeneration of nerve-fibers we hold, the approximation of the ends of a divided nerve-trunk and holding them in approximation is the only way in which repair of the nerve-trunk and recovery of function can take place. Nerve suture is the only sure way of accomplishing this in case of complete section. *Primary suture should always be performed* when possible, for it is safe and gives the best functional result the most speedily. In case primary suture has not been performed or is not successful, secondary suture is indicated in nearly every case. If not sutured, the divided ends are likely not to unite or to unite imperfectly. The causes of failure are sloughing of the ends of the nerve and profuse suppuration. The first is treated by secondary suture, the second by excision of compressing scar tissue, nerve-stretching, and later, if unsuccessful, by secondary suture. In case of lacerated wounds remove all parts of the nerve too damaged to recover. If, after thorough stretching, the ends cannot be brought together, we have the choice between nerve splicing (neuroplasty), anastomosis of the peripheral end into an adjoining intact nerve, shortening the bones of the limb by a resection of enough of the bone to allow the ends of the nerves to be approximated, etc. After nerve suture, primary or secondary, massage of the muscles, passive motion, douches, and electricity—first the galvanic and later the faradic current—should be employed daily. These means hasten the functional recovery and improve the prognosis, and it is of the greatest importance as to the result that they should be faithfully carried out for a long time. For the technic see Nerve Suture.

Prognosis.—The probability is that the function of the nerve will be restored in the great majority of cases if the wound heals by primary union. If profuse suppuration occurs, the functional recovery is likely to be imperfect or even wholly absent. This is due to the formation of dense scar tissue surrounding and compressing the point of union or interposed between the ends of the nerve, separated by reason of the suppuration or of the sloughing of the nerve-ends. "The clinical as well as the physiological evidence is against the possibility of immediate union,"[32] for the distal portion always degenerates whether sutured or not. The prognosis is better the younger the patient. Apparently some nerves offer a better prognosis than others. We can predict that sensation will return before motion. The sense of touch may be noticed very soon after the operation—within twenty-four hours,[2] but usually after two to seven days. At first this is far from delicate, and the points of contact cannot be properly localized. In secondary suture it continues to improve, while in primary suture it may diminish and disappear again until regeneration begins in the nerve. In four to eight weeks it is quite good. The sensations of pain and temperature return later than those of touch. The return of motion is said to have commenced as early as sixteen days after operation, but it is not usually noticed for two months and may be delayed much longer. It is not complete for one or more years. It is longer and slower in its return when the muscles have been allowed to atrophy and have not been treated by massage, electricity, etc., as in many cases of secondary suture. The amount of the return of motion varies from a feeble movement of some muscles to nearly perfect use of all. Complete function is rarely, if ever, restored; the ability to do delicate work does not return. No case is hopeless until the lapse of two or three years, and not even then if any improvement is in progress.

In any given case we cannot say how much time must elapse before recovery, but considerable improvement, even up to the limit of recovery, may be expected within a year. In answer to the question as to how long we should wait before resorting to secondary suture in the case of a divided nerve when the original wound has healed by first intention Horsely[33] advises to wait for eighteen months.

Contusion of Nerves.—In severe contusion the effects are the same as in division. Most, if not all, the nerve-fibers are severed, and those still remaining are so injured or afterward compressed by the extravasation of blood and inflammatory exudates as to undergo degeneration. The conductivity of the nerve is lost. The nerve-sheath may remain intact. It is much thickened in the process of healing and its lumen may even be obliterated by new connective tissue. In less severe contusions some nerve-fibers are severed, others are injured so that they degenerate, while the majority lose their conductivity only temporarily. Here again some extravasation of blood and plastic exudate occurs and the connective tissue of the nerve is liable to be increased. Again, in mild contusions, as in the familiar one of contusion of the ulnar nerve at the elbow, the conductivity is not lost or only momentarily—there is merely a sensation of numbness, tingling, and burning for a moment or two and there may be and probably is no gross lesion of the nerve—merely a mechanic disturbance of the fibers.

Symptoms.—After slight contusions there is local pain at the point of the contusion,—owing to the injury of the nervi nervorum,—numbness, tingling, and often a sense of heat and flushing in the peripheral distribution of the nerve. These symptoms pass off rapidly. If the contusion is more severe, they may remain several days. In still more severe contusions there is paralysis of motion and sensation, and the latter is often less pronounced than the former, for sensation is conveyed in injured as in imperfectly regenerated nerve-fibers more readily than motor impulses.[34] The paralysis may quickly disappear after a few days, or slight paralysis may persist and symptoms of neuritis appear with its trophic changes. In the most severe cases the paralysis is complete and persists until regeneration. Paralysis of the deltoid after a fall on the shoulder is a not uncommon example of contusion of a nerve. Paralysis of the brachial plexus or cervical nerves, of the facial nerve after instrumental delivery, and of nerves in the vicinity of a fracture or dislocation, may be due to a contusion. In the latter case the symptoms of paralysis of varying degrees come on at once, but in the cases of gradual compression from the bone or callus they come on at a later period. Rapid compression of a nerve, as the accidental compression of a nerve by a ligature or pressure forceps, is essentially a contusion in the nature and results of the lesion.

The **prognosis** is difficult except in the mildest cases. If the paralysis is not complete or disappears after a few days, the nerve is not seriously crushed. The electric reaction is useful in prognosis. If the reaction of degeneration is present and if, in addition, rapid atrophy of the muscles occurs, the prognosis is unfavorable and a long time will be required for recovery. If, after a week or more, the muscles still respond to faradic stimulation, there is not complete loss of continuity and a rapid and complete recovery may occur. If the faradic excitability rapidly disappears but the paralysis of all the muscles supplied by the nerve is not complete, the nerve-trunk is not completely crushed. In severe cases the improvement is likely to stop short of complete recovery, owing to the considerable formation of fibrous tissue at the site of the lesion. The condition of the patient may go from bad to worse, owing to the occurrence of neuritis, which is not probable but cannot be foretold.

Treatment.—This consists in limiting and arresting inflammation by rest, secured by splints and bandages, and local antiphlogistic applications to the surrounding bruised tissues, such as compresses of alcohol, 50 per cent., aluminium acetate, 5 per cent., or lead and opium. This has the additional advantage of tending to prevent a neuritis and the formation of a large mass of scar tissue. If pain is severe and is not relieved by the above treatment, morphin may be given hypodermatically into the nearby healthy tissues. Subsequently, as soon as the inflammation has subsided, electricity, friction, massage, and counterirritants should be used. Galvanism is more effective than faradism. If symptoms of inflammatory adhesions or chronic neuritis persist, expose the nerve, ascertain its condition, whether adhesions or thickening are present, dissect it free from compressing scar tissue, and employ nerve-stretching. If after a severe injury the electric reactions indicate complete loss of continuity, the treatment becomes that of an incised wound, with this difference that, as the nerve sheath is probably not torn, the ends of the nerve-fibers are not far apart and the chances of reunion are thereby increased. But since regeneration is apt to be imperfect and improvement stops far short of a cure, the treatment of the nerve by suture, after inflammatory symptoms have subsided, promises better results than the expectant plan.

Compression of Nerves.—The lesion due to *gradual or slow compression* can hardly be other than a mere mechanic disturbance of the nerve-fibers, which may speedily return to normal, as Van Lier[35] has demonstrated experimentally.

The **symptoms** produced by a gradual compression are prickling and tingling, with numbness and warmth in the area of distribution. Then follow hyperesthesia of all sensations and muscular twitchings. As the compression continues the conductivity is gradually lost, producing anesthesia and paralysis, preceded by painful cramps. If the compression is removed, the anesthesia and paralysis subside after a variable time, depending on the duration and degree of compression. Hyperesthesia may occur before sensation is normal; motion returns more slowly and cramps are often present. If the compression continues long enough, as in compression by callus or a scar, muscular atrophy as well as other trophic changes may occur.

The commonest example of nerve compression is the "crutch paralysis" from the compression of the nerve between the upper end of the crutch and that of the humerus. In such cases numbness and tingling in one or more fingers are followed by weakness, which often affects one group of muscles more than others, depending upon the particular nerve compressed. Hence some muscles (*i. e.*, those least involved) recover more rapidly than others. Motion may be affected without sensation, but, as a rule, sensation is first affected and first recovers. Sometimes there is pain at the point of pressure in the axilla. If the improper use of crutches is persisted in, the paralysis may become absolute. The prognosis, as a rule, is good. Similar symptoms may follow the compression of the nerves when the arms are held under the head or over the back of a chair during heavy sleep. One or more nerves may be affected, and the paralysis and anesthesia may be partial or complete. The prognosis is not so good as in crutch paralysis; the paralysis improves slowly and may not be entirely recovered from. Compression from the prolonged application of a too narrow elastic tourniquet, from the forcible holding of the arms above the head or their pressure against the edge of the table during prolonged anesthesia, or from pressure of the peroneal nerve against the fibula, may produce similar results. Common causes of compression of nerves are seen in dislocations, especially of the head of the humerus, in fractures, especially of the shaft of the humerus, and in cicatrices, even when the nerve was not exposed in the original wound. In cicatrices, during or after healing of the wound, neuralgia or shooting pain, with numbness and tingling in the periphery, are usually the first symptoms followed by muscular twitching, cramps, and paresis. As additional causes may be mentioned tumors of or near nerves, aneurisms, enlarged glands, inflammatory exudates, cervical ribs, improperly applied splints. The compression depends more or less upon the inability of the nerves to be pushed to one side and stretched and on the rapidity of growth of the tumor, aneurism, etc.

The **treatment** of compression of nerves is essentially the removal of the cause. Galvanism, massage, and friction hasten functional recovery. If the symptoms in part persist, from inflammatory adhesions or thickening of the sheath or the complication of chronic neuritis, expose the nerve, uncovering it first above and below to avoid accidental injury when it is abnormal, dissect it free of adhesions, and stretch it. In such cases use great care to secure primary union of the wound to avoid recurrence of adhesions, scar pressure, etc.

Stretching of a nerve as an accident occurs only in certain parts of the body—the brachial plexus in the posterior cervical triangle, the nerves of the axilla in some dislocations, the sciatic, etc.

The lesions produced by stretching are: (1) The sheath is partly loosened from attachment to the nerve and from its adhesion to surrounding parts; (2) the sheath is narrowed and thereby constricts the nerve-fibers; (3) the blood-vessels of the sheath are partly torn, resulting in ecchymosis; in time the nerve becomes more vascular by the formation of new blood-vessels; (4) more or less of the nerve-fibers may be torn and hence undergo degeneration. The axis-cylinder breaks less readily than its coats. According to Virnicchi's experiments,[36] the sheath of Schwann stretches until the nodes of Ranvier disappear and then ruptures with the rest of the fiber, but not always at the same point as the axis-cylinder. The peripheral fibers are more injured than the central ones. In the cord the main strain of stretching is borne by the dura; if this yields, a slight force tears the roots from the cord.

The **physiologic effects** when a nerve is slightly stretched is a slight increase of excitability. As the stretching increases the excitability is diminished until it is finally lost. Motion and sensation are partly or entirely paralyzed; motion may be more affected than sensation, or vice versâ. Pain in the nerve-trunk and its peripheral distribution is caused by the stretching of the nervi nervorum and the peripheral sensory fibers respectively. Anesthesia may be rapidly recovered from when almost complete. It is claimed[37] that in stretching a nerve away from the cord anesthesia is more marked than motor paralysis, and vice versâ.

The effect on the spinal cord and the opposite sciatic are matters of contrary opinion. Stinzing[38] says that it increases the sensory and motor excitability of the opposite sciatic. In rare cases in the human subject the motor and sensory function of the opposite sciatic have been transiently altered in the same way as those of the nerve stretched. Except in the case of the sciatic, no effect on the nerve of the opposite side is observed in nerve-stretching, and in the sciatic only when more force is used than should be.

Nerve-stretching is also used as a method of *treatment* in certain painful conditions, such as neuritis of those peripheral nerves whose function contraindicates resection, especially neuritic sciatica. As a therapeutic measure it may act—(1) By increasing the vascularity and improving the nutrition of the nerve; (2) by separating the nerve-trunk from surrounding adhesions or cicatrices; (3) by traction on the nervi nervorum, separating them from adhesion to the nerve-sheath; (4) by partial or complete laceration of nerve-fibers in different nerve bundles, and in several other possible ways.

The treatment of accidental stretching is rest. Later, electricity and massage may be employed if the symptoms have not entirely disappeared.

INJURIES AND DISEASES OF SPECIAL NERVES.

The Fifth Cranial Nerve.—Isolated **injury** of this nerve is comparatively rare. It may occur in fracture of the maxilla, rarely of the lower jaw. In connection with the injury of other neighboring nerves it is rarely injured in fractures of the base. The symptoms consist of anesthesia with or without pain.

Neuritis of the trigeminal nerve is only too frequent as the commonest cause of trigeminal neuralgia, especially of tic douloureux[39] (p. 696).

Herpes zoster of the fifth nerve, secondary to a lesion of the Gasserian ganglion or a neuritis of a peripheral branch, is not uncommon. It may affect the area of one or more branches of the nerve, and is named accordingly, herpes frontalis corresponding to the supra-orbital branch, herpes facialis to the infra-orbital division, herpes ophthalmicus to the branches distributed to the eye. The pain is a very marked feature; in fact, the herpes may be an accompaniment of an attack of trifacial neuralgia. The diagnosis is easy, and the treatment like that of herpes zoster elsewhere or of trifacial neuralgia.

The Facial Nerve.—Owing to its long course through the bony Fallopian canal, the facial is the nerve most frequently injured in fractures of the base of the skull. This injury was observed 10 times out of 11 cases of nerve injury in 58 fractures,[40] and 22 times in 48 fractures.[41] Other nerves, especially the eighth and sixth, are often injured at the same time. The result of such injury is a paralysis or paresis of the facial muscles of the same side. If the nerve is torn across, the paralysis is complete and will probably be permanent; if there is only paresis, the nerve may have been stretched or compressed by a clot and improvement or recovery will follow. According as one or another of the branches of the nerve given off in this canal are involved or not, we may determine more accurately the position of the nerve lesion, as well as the course of the fracture. If the nerve lesion is above the chorda tympani branch, there is loss of taste in the anterior half of the tongue; if above the stapedius branch, the tensor tympani is unopposed and there is, in addition, hyperacusis or great sensitiveness to sound. If the lesion is central to the geniculate ganglion, there is paralysis of the palatal muscles (denied by some), but the sense of taste is intact. The facial nerve is also injured in surgical operations about the antrum and parotid region, by bullet and stab wounds which traverse its course, and by forceps pressure at birth. Facial paralysis occasionally develops, subsequent to an injury, from an ascending neuritis which may advance and set up a basilar meningitis. Again, it may be due to a central or cortical lesion, such as hemorrhage, tumor, softening, etc., in which case the temporal branch is unaffected; the adjacent motor areas, especially that of the arm, are usually involved, and the electric excitability is present.

Peripheral facial paralysis (Bell's palsy) is the common form. Many cases are due to traumatism, but the most frequent causes are exposure to a draft and infection. The predisposition of the individual to this affection is ascribed to a "rheumatic taint" or a "neuropathic tendency." It is most common in winter, and in males between twenty and forty years of age.

In the few cases in which the affected nerve has been examined, a degenerative or diffuse neuritis has been found extending as high as the geniculate ganglion and beginning, it is thought, peripherally (Minkowski).

L. Pierce Clark[43] states that "there was good reason to believe that Bell's palsy was primarily a Fallopian neuritis which, through strangulation of the nerve strands, induced a low grade of secondary degenerative neuritis in the periphery." It is probable that this form of facial palsy is of infectious and not of rheumatic origin.

Symptoms of the non-traumatic form come on quite suddenly and are fully developed in a few hours or a day or two. Before and with the onset there may be a feeling of fullness and puffiness on the affected side of the face, and some pain about the ear. When fully developed, the appearance is characteristic. The eye cannot be closed, the brow wrinkled, or the mouth puckered on the affected side. The angle of the mouth droops a little and is drawn toward the sound side. The nasolabial fold and other facial wrinkles are obliterated, and the nostril does not expand. The eyeball is rolled up in attempting to close the eye. These are brought out most clearly in laughing or other emotional movements or when the patient tries to close the eye or to whistle. In addition the eye is often inflamed and watery, the tears overflow the lower lid, and, owing to paralysis of the buccinator, food is apt to collect between the teeth and the cheek. In other cases, depending upon the distance that the lesion extends up the Fallopian canal, taste is impaired in the anterior half of the tongue, the hearing may be hyperacute, and, less commonly, half of the velum palati and uvula is paralyzed. Some wasting of the face may be noted after a few weeks.

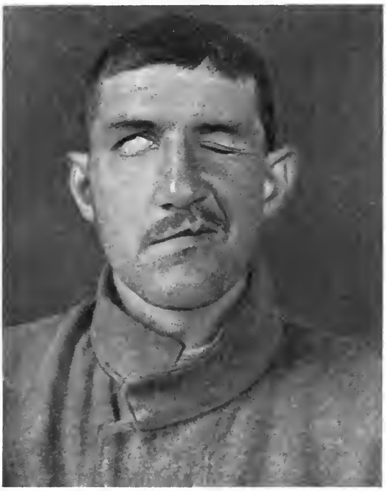


Fig. 538.—Facial Paralysis.
Six weeks after injury. Effort to close eye (Harvey Cushing).

The *electric reactions* are important and characteristic, though they vary with the severity of the case from a normal irritability of muscles and nerve to the complete reaction of degeneration. Usually partial or typical degenerations are observed, following an increase of irritability for a few days. After five or six weeks the return of faradic irritability should begin, but in severe cases this period may be considerably delayed.

When the palsy is not complete and has lasted two months or more, contractures of the facial muscles begin to occur, drawing the mouth to the affected side and deepening the nasolabial fold. Spasms of the muscles on the affected side may also occur irregularly, resembling facial tic convulsif.

The *diagnosis* is easy on making the patient laugh. The distinction between facial palsy of central and peripheral origin can readily be made from the differences mentioned above.

The *prognosis* in Bell's palsy is good, but the recovery is often incomplete. Though mild cases may be well in a month, the average duration is three to five months. The electric reaction helps us to prognosticate the duration of the attack. If the electric excitability is unchanged, recovery is likely to result in two to four weeks. The more complete and persistent the degenerative reaction, the worse the prognosis. In some cases complete or nearly complete palsy persists.

The *treatment* of facial paralysis depends upon the cause, which should be removed in cases due to ear trouble, syphilis, etc.

In "Bell's palsy," if the electric excitability is unchanged, no treatment is necessary. The more severe cases should be treated like an infection, with purgatives and diuretics, hot fomentations, and perhaps a blister over the point of exit of the nerve. After a week or so, when the reaction of degeneration is present, the galvanic current should be employed for five minutes daily by applying the anode between the mastoid process and the lobe of the ear and the cathode over the same point on the opposite side. Or a medium-sized electrode may be applied over the back of the neck, while a small electrode (anode) is slowly passed over the muscles. The current should not be strong enough to produce pain or vertigo. When, after a few weeks, the electric excitability has begun to return, the faradic current may be used either on the nerve or the muscles.

When the paralysis remains nearly or quite complete, the question of *nerve anastomosis* should be considered. If the paralysis is due to a bullet or stab wound, a surgical operation, or other evident traumatic cause, in case the ends of the nerve cannot be directly sutured,—and they usually cannot be,—the operation should be performed early, if possible before marked atrophy and degeneration of the muscles have occurred. In non-traumatic cases of Bell's palsy, or those due to ear disease, operation is not to be recommended[44] until six months after the onset of the palsy, and only when the return of function has been very slight, so that the facial muscles are still nearly completely paralyzed and the reaction of degeneration is very marked. McGregor[45] reports an exceptional otitic case of three years' standing cured by a radical operation on the middle ear. As a rule, when the palsy has lasted a number of years, nerve anastomosis offers little hope of a functional result, for the muscles are so wasted that there is but little muscle tissue to contract. Hence in any case of doubtful recovery the tone of the paralyzed muscles should be preserved by massage and electricity. Frazier[44] stated in 1903 that up to that time three years was the longest period after which the nerve function was restored in part. But Hackenbruch[46] reports a favorable result after the paralysis had existed seven and three-fourth years, Taylor one after twelve years, and Elsberg[47] one after twenty-nine and one-half years.

Mr. Ballance, of London, was the first to do a facial anastomosis on the human subject in 1895—facio-accessory anastomosis. Bardenheuer,[48] in 1904, collected 25 cases, including two of his own, and the many other cases since then reported would largely swell this number. While it is abundantly proved that the peripheral end of the paralyzed facial nerve may be sucessfully anastomosed with a neighboring healthy nerve, the points still in dispute are what nerve to anastomose with—spinal accessory or hypoglossal*—and how to anastomose, end to end or end to side.

The Choice of the Nerve to be Employed.—The *advantages* of the *spinal accessory nerve* for anastomosis with the facial are that it is easily reached and united with the facial and the loss of its function is relatively unimportant, as its division causes only an inability to raise the arm above the horizontal, which soon disappears, some drooping of the shoulder, and partial atrophy of the sternomastoid and trapezius muscles.

The chief *objection* to the use of the accessorius is that movements of the shoulder are not usually possible without those of the face, and to some extent vice versâ. In Cushing's case[49] a forcible elevation of the shoulder caused an incoördinate contraction of all the facial muscles, while coordinate movements of the face could be made without elevation of the shoulder. These associated movements occur whether the accessory nerve is completely or partially divided and united to the facial end to end, or not divided and an end-to-side anastomosis made. Exceptions to this rule, where there were no associated movements, have been recorded by Mintz[50] and by Elsberg.[47] This associated action is owing to the fact that the cortical center of the spinal accessory is not a center for this nerve alone, but for the movements of the shoulder, which includes other nerves. When an impulse originates in this center to move the shoulder, the face is also stimulated to action, through the accessorius, and vice versâ. Although in time the cortical center is capable of being educated to its new function and the associated shoulder movements are less pronounced, the cases are rare where these movements, once present, have become entirely dissociated. A patient operated on by Martin[51] learned to dissociate completely the voluntary movements of the face and shoulder. This would be more likely to occur in young than in old patients.

The advantages of the *hypoglossal* lie in the direction of the disadvantages of the accessorius. The cortical centers of the hypoglossal and facial are nearer one another and more similar in function and, *a priori*, it would seem as if the former could be better reëducated to perform the functions of the latter than could that of the spinal accessory. On the other hand, complete division of the hypoglossal causes paralysis with atrophy of half the tongue, which affects the speech and at first the act of swallowing. Hence in my own judgment we are not justified in completely dividing the hypoglossal to make an end-to-end anastomosis, especially as there is always some doubt as to the success of operation from a functional standpoint. As in Körte's case,[52] associated movements of the tongue with those of the face are also to be expected.

The opinion of surgeons is divided as to which nerve to prefer for the anastomosis, the accessory or the hypoglossal. Körte,[53] after employing the hypoglossal, stated that the accessory is to be preferred. Frazier[44] and Taylor prefer the hypoglossal, as do Ballance and Stewart, who were the first to suggest and perform the faciohypoglossal anastomosis. To secure regeneration of the facial nerve we may employ any of the first

* Shaffer employed the glossopharyngeal for the anastomosis.

three varieties of anastomosis (p. 752). End-to-end anastomosis may give the best result, but is objectionable if the intact nerve is completely divided unless we use the accessory. Lateral anastomosis (peripheral implantation) is the safest method in the sense that less damage is done, though the functional result in the paralyzed nerve may, possibly, not be quite so perfect.

Dollinger[54] recommends using the branch of the accessory to the trapezius, cutting it long and turning it up, so as to avoid paralysis and atrophy of the sternomastoid, and this was the method employed in Faure's first case.

The *results* are encouraging. They vary with the age of the patient, the duration of the palsy, the degree of asepsis, the form of the anastomosis, and the technic. We are not yet in a position to state categorically which form of anastomosis and which nerve should be selected. On the whole, the lateral anastomosis of the facial with the hypoglossal is at present the most approved form. Mintz[50] found 7 failures among 22 facial anastomosis operations. The first result of a successful anastomosis is the restoration of the normal muscle tone and the symmetry of the face in repose, in place of the previous flaccidity and asymmetry. The next stage of improvement consists in the voluntary control of the facial muscles, enabling the patient to close the eye in winking, pucker the mouth in whistling, etc. These results are to be expected in a more or less complete degree in case the technic of the operation has been good and the healing aseptic. A complete recovery would involve a restoration of the function of the muscles in the movements of expression and emotion. This is not to be expected, at least at all perfectly. It would require the education of the new cortical centers in movements of delicate coördination and would be more possible in young patients.

The Operation of Facio-accessory or Facio-hypoglossal Anastomosis.—(1) Incision through the skin and subcutaneous tissues along the anterior border of the sternomastoid muscle from a point 2 cm. above the tip of the mastoid to a point opposite the upper border of the thyroid cartilage.

(2) The *facial nerve* is sought by retracting the sternomastoid backward and the parotid gland forward. The nerve is found entering the gland about 1 cm. above and 1 cm. internal to the tip of the mastoid. Cushing[49] advises carefully incising the posteror border of the parotid directly beneath and parallel with the skin incision. In this incision, carefully deepened, one of the two chief branches of the nerve is certain to be found, and is then followed back to the main trunk by blunt dissection without traumatism to the nerve. The nerve-trunk is followed back, held up on a small blunt hook, and two fine silk sutures are passed through the sheath just distal to the point of division, as near the stylomastoid foramen as possible.[55]

(3) *The accessory nerve* is easily exposed at its point of entry into the deep surface of the sternomastoid muscle, about 5 cm. below the mastoid tip. Above this point the nerve is found beneath the deep fascia, directly below the transverse process of the atlas, where it is covered by the posterior

belly of the digastric. The entire nerve may be divided, after passing two sutures of finest silk through its sheath, a little proximal to the point of division, or the branch to the trapezius may be employed or the nerve may be partly divided and split up from this point proximally. In any case a sufficient length of nerve is dissected up so that it may be united without tension by end-to-end suture with the distal facial stump over the pos-

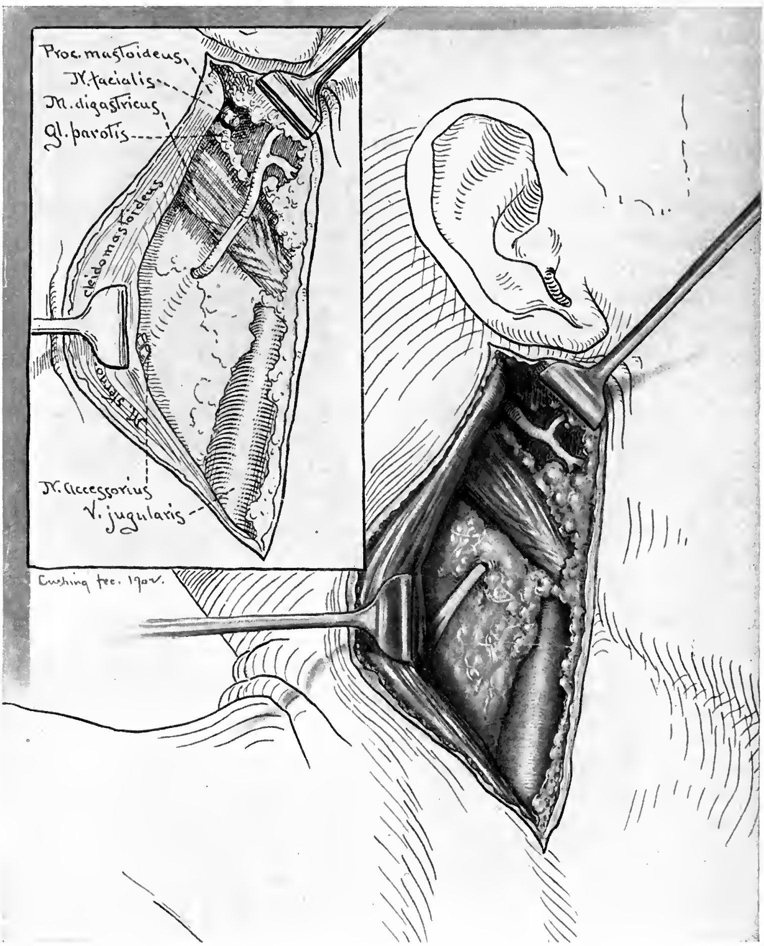


FIG. 539.—ILLUSTRATING METHOD OF SPINOFACIAL ANASTOMOSIS (Harvey Cushing).

terior belly of the digastric muscle. To facilitate the anastomosis Mintz[50] divided the posterior belly of the digastric and Villar[56] carried the accessory stump up under the muscle.

(4) The *hypoglossal nerve* lies more deeply and is not so easy to expose. The posterior belly of the digastric and the occipital artery serve as landmarks for the nerve, which is exposed just below the former as it curves

forward under the latter to cross the external carotid artery. It is dissected up carefully until the stump of the facial, cut as long as possible, can be approximated to it without tension. The distal facial stump is anastomosed laterally into the hypoglossal. (For the technic see Nerve Anastomosis, p. 754.)

It is essential to manipulate the nerves with extreme delicacy, to avoid undue traumatism, to use a minimum number of sutures of finest silk passed by fine curved round needles through the nerve-sheath only, to secure perfect apposition, and especially an aseptic wound healing. Even with the above technic there is more or less palsy of the muscles supplied by the hypoglossal, which may continue for several weeks, during which time there is difficulty in talking, swallowing, and mastication, and the tongue is furred unilaterally. The treatment after healing of the wound is no less important than the operation. Massage, electricity, and later on coordinate muscle movements should be systematically employed for months.

Facial spasm, tic convulsif, mimic tic, is a chronic affection characterized by involuntary, intermittent twitchings of a few or many of the facial muscles, generally on one side only.

It occurs oftener in women of a neuropathic constitution and in middle or later life. Injury, mental shock, anxiety, reflex agencies, such as irritation of neighboring nerves, act as exciting causes. It may also be due to an irritation or disease of the facial nerve or its nucleus. In most cases there is no discoverable organic lesion.

Symptoms.—The disease begins in the orbicularis and zygomatic muscles and advances slowly, rarely going above the eyebrows or involving the lower branch of the facial. The spasms are clonic and painless, and occur in series of lightning-like twitches with intervals of rest. The spasms may sometimes become tonic. They are increased by excitement, emotions, exposure to cold, and a depressed state of the nervous system. There are no paralyses or trophic disturbances; the electric irritability is unaffected or somewhat increased. Movements of the eyes, jaws, tongue, and neck may sometimes be associated with the facial spasm.

Prognosis.—The disease may last for years or a lifetime; it is usually incurable, but does not endanger life. The prognosis is better if a reflex cause exists.

Treatment.—A careful examination for a possible reflex cause in the teeth, eyes, nose, stomach, uterus, etc., should be made and such causes removed. Attention to the general health, removal of depressing influences, freedom from fatigue and excitement are most important. Drug treatment and surgical treatment by neurectomy or nerve-stretching are conspicuously unsatisfactory, though some amelioration and transient relief may be obtained. Galvanism, used daily, is said by Dana almost always to help.

The facial nerve may be exposed for stretching as it is for anastomosis (p. 754), but it is not necessary to follow it up so close to the foramen. It should be stretched in both a central and distal direction by a blunt hook or piece of rubber tubing passed beneath it. No result is to be expected in about 60 per cent. of cases, improvement in 30 per cent., and cure in only 10 per cent., from stretching the facial nerve.

Division of the facial nerve and anastomosis with the accessory (or hypoglossal) nerve, as successfully employed by Kennedy,[57] offer the best outlook for cure, and one worthy of trial when other milder means are without avail.

The Eighth or Auditory Nerve.—Isolated injury of the auditory nerve in head injuries is rare; the facial nerve is usually injured at the same time—in 6 out of 9 cases (A. Heer).

Deafness in one ear and facial paralysis of the same side without loss of taste point to injury of both nerves near the internal meatus.

Slowly progressive unilateral deafness may be due to the pressure of a neurofibroma of the nerve in the pontomedullocerebellar space.[42]

Persistent *tinnitus aurium* may be due to a variety of causes. The symptom is described by its name. It often resists the treatment by bromids, nitroglycerin, digitalis, etc. In such cases the auditory nerve has been isolated from the facial, above and in front of it, pulled back, and divided intracranially by Krause and others.[58]

The Spinal Accessory Nerve.—The external branch of this nerve may be injured in operations for the removal of tumors or enlarged glands behind or in front of the upper half of the sternomastoid. The results are not uniform. When the whole nerve is divided, in some cases the sternomastoid and trapezius are completely paralyzed, while in others the paralysis is only partial. This is explained by the fact that these muscles are also supplied by branches from the second, third, and fourth cervical nerves, which sometimes join the accessory nerve before its entrance into the sternomastoid and sometimes supply these muscles directly. Atrophy of the muscles affected follows their paralysis. Paralytic torticollis may occasionally result from this injury.

Spasmodic torticollis, or wry neck, is due to an irritation of the accessorius, usually of central origin. (See Torticollis, Vol. III.) In the treatment of this affection stretching or neurectomy of the nerve or both (Schwartze) are often employed.

Cervical Nerves.—**Spasmodic torticollis** may affect the muscular branches of the cervical nerves as well as the accessorius, the nerves so affected being mostly the muscular branches of the posterior primary divisions. Keen has devised an operation for resection of these nerves for the cure of such cases. (See Torticollis, Vol. III.)

Cervico-occipital neuralgia affects the sensory branches of the upper four cervical nerves. The internal (sensory) branches of the posterior primary divisions of these nerves, including the great and third occipital nerves, are most involved. The small occipital and the auricularis magnus, sensory branches of the cervical plexus, are often equally affected.

The nature of the pain, its causes, its intensity, and the presence of painful points are in the main the same as in trigeminal neuralgia. The pain is usually unilateral, involving the back and side of the head and neck. This form of neuralgia occurs between the ages of twenty and thirty-five, is more common in women, and is often of reflex origin, especially from pelvic disease. The disease may last five or six weeks, or it may become chronic, especially when of reflex origin. The pain may take the place of or alternate with trigeminal neuralgia.

Diagnosis.—It is to be distinguished from the boring pains of spinal irritation and hysteria, the tired ache of neurasthenia, and from the pain of ear disease, eye-strain, and vertebral caries. The unilateral and neuralgic character of the pain is usually diagnostic. In the etiology, prognosis, and general treatment the condition is similar to trigeminal neuralgia. Reflex causes, especially in the pelvis and eye, should be sought for and removed. In obstinate cases neurectomy of the affected nerves should be performed as close to the spine as possible, to include any anastomosing branches that may continue the neuralgia. When the neuralgia continues in spite of a thorough neurectomy of the affected nerves, a division of the posterior nerve-roots within the vertebral canal should be tried.

The **phrenic nerve,** derived from the third, fourth, and fifth cervical nerves, is the most important motor branch of the cervical plexus, and may be injured in bullet and stab wounds of the neck and thorax and in surgical operations. Injury of one phrenic nerve causes paralysis of the diaphragm on that side, as its intercostal nerve supply is insufficient. This paralysis is usually recognized only by careful examination, as such patients can breathe deeply by the aid of the thoracic muscles. Many have supposed that the injury of one phrenic nerve was a fatal injury, but it has been proved otherwise by experimental and clinical observations.[59] It is quite probable that the diaphragm is not an essential muscle of respiration, and though death follows immediately the paralysis of both phrenics experimentally produced in animals, it is very probable that it is not necessarily immediately fatal in man.

The **pneumogastric nerve** may be divided, tied, or otherwise injured in the removal of malignant tumors, in the ligature of the carotid, or in stab or gunshot wounds. After the division of one vagus there is usually no effect on the pulse, respiration, or digestive organs. The most constant effect is a paralysis of the vocal chord on that side, with hoarseness. If the injury be above the origin of the superior laryngeal nerve, anesthesia of the mucosa of the larynx and paralysis of the epiglottis on the same side would result. If both vagi are divided or injured, death ensues from paralysis of the glottis, tachycardia, very slow respiration with edema of the lungs, pneumonia, etc. Sudden *contusion* of the nerve may be followed by serious symptoms—sudden arrest of heart action and respiration. Two such cases reported by Tillman[60] and Michaux recovered after removal of the ligature or clamp. Jordan[61] collected 7 cases of bullet wound of the vagus and 23 of division during excision of tumors. In none of the latter was death directly due to the injury of the vagus. Crile[62] collected 6 cases of division of the vagus with little or no effect on the pulse or respiration, except in one case from irritation, and none of them was fatal. While, therefore, unilateral division of the vagus is a procedure free from danger, the nerve should be resected only when inseparably adherent to malignant growths. *Irritation* of the vagus may produce one or more of the following symptoms: slowing of the respiration, severe coughing, slowing of the pulse (with rise in blood pressure), and vomiting.[63]

The **recurrent laryngeal branch** is liable to injury or division in tying the inferior thyroid artery, beneath which the nerve lies, and in thyroidectomy. (See Vol. III.) The symptoms are hoarseness and often temporary aphonia, due to paralysis of the vocal chord on the same side. If both nerves are divided, paralysis of the glottis results, which is fatal if unrelieved by immediate intubation or tracheotomy.

The **hypoglossal nerve** is subject to injury in wounds of the submaxillary region, such as cut-throat and bullet wounds. Paralysis and atrophy of half the tongue result. Wölfler[64] reports a successful secondary suture of the hypoglossal and collected 6 cases of its injury.

The Brachial Plexus.—This is subject to any of the injuries to which nerves are liable. These injuries occur most often in men, and are also common in infancy, in brachial birth palsies. They produce a paralysis of the arm varying from a total paralysis to the more common palsies of a few muscles, depending upon the extent of the nerve lesion.

Etiology.—Incised and punctured wounds of the brachial plexus are not very common, and are illustrated by stab and bullet wounds. Contusions from heavy objects falling on the shoulder or from falls on the supraclavicular region are more commonly reported, but there is often reason to question whether the true mechanism is not an overstretching due to the forcing of the head away from the shoulder, or a combination of contusion and stretching. Many cases are attributed to compression or contusion between the clavicle and the first rib or the cervical transverse processes. Clark, Taylor, and Prout[66] show that this cannot be the mechanism in birth palsies, and it is doubtful if it occurs in the adult, except in connection with fracture of the clavicle. Stimson[67] found only a very few cases reported in which the symptoms came on at the time of fracture, and in some of these there was a paralysis of the suprascapular nerve, which lies well above the clavicle and suggests an injury by stretching or laceration. In case of possible compression or contusion of the plexus between the clavicle and first rib, without fracture of the former, the lower or inner cords would suffer first and foremost and a lower arm palsy result. Compression paralyses do occur from displaced fragments, exuberant callus, an axillary pad, crutches, shoulder dislocations, cervical ribs, hematomata, inflammations, tumors, and the contraction of cicatrices. By far the commonest cause of *brachial palsy* is a stretching or laceration of the plexus, sometimes over the head of the humerus, as in the anesthesia palsies, but more commonly by a pressure or traction which forces the head and neck away from the shoulder. It can be readily proved that this puts the plexus on the stretch, but first and especially its upper roots. In luxations of the cervical vertebræ a nerve-root may be torn, overstretched, or compressed.[67]

The **pathology** of the lesion is the same as that of similar lesions of nerves elsewhere. (See Wounds of Nerves.) In the lesion due to overstretching or laceration it should be observed that the nerve sheath gives way first with the blood-vessels it contains, causing hemorrhage into and beneath it. The nerve strands are partly or completely torn at different levels, so that the lesion extends over a considerable space. The deep cervical fascia overlying the plexus is often torn. The cicatricial contraction incidental to the healing of the nerve-sheath and the organization of the blood-clots prevents the regeneration of the nerve and may cause a neuritis in the nerve strands that have not given way.

The **symptoms** vary with the extent and severity of the lesion. The paralysis is the chief symptom. This may be total or partial, permanent or transient. In mild cases, as after sleeping on the arm, the palsy, though total, may quickly disappear. In more severe cases, as in anesthesia palsy, the paralysis is total and may require four or five months for complete recovery. In most cases of brachial palsy the paralysis is partial, or if complete at first, many of the muscles in time (three to five months) regain their power, their nerves not having been torn, leaving only a certain group paralyzed. In the most severe and not very common form of injury, the avulsion of the entire brachial plexus,[68] the complete paralysis is permanent. The *type* of the paralysis depends upon the particular parts of the plexus involved. There are three general types of brachial palsies: (1) Total arm palsies; (2) upper arm palsies (Duchenne-Erb palsy); (3) lower arm palsies. The common type is the upper arm palsy (Duchenne-Erb type), in which the fifth and sixth cervical nerve-roots, or the cord formed by their junction, is the site of the lesion, as these parts suffer from the traction first and foremost when the neck is forced away from the shoulder. The muscles affected do not belong to the distribution of any single nerve-trunk. In the common upper-arm type there is paralysis of the deltoid, supraspinatus, infraspinatus, teres minor, biceps, brachialis anticus, brachioradialis (supinator longus) and supinator brevis muscles, so that the arm cannot be abducted or rotated out, and the forearm cannot be flexed or supinated. Thus the arm is adducted and rotated inward at the shoulder; and the forearm is pronated and extended at the elbow. The paralyzed muscles undergo atrophy, and the development of the arm is more or less inhibited in cases occurring early in life (brachial birth palsies).

The sensory changes do not correspond with the motor. Thus in the Duchenne-Erb type of palsy there may be little or no anesthesia, owing to the overlapping of the segmental cord supply to the skin and to nerve anastomoses producing the so-called "supplementary sensation." Even in more complete types of arm palsy the sensation may be surprisingly little affected. In complete avulsion no sensation may remain except in the intercostohumeral area.

Changes in electric reaction accompany the paralysis. Pain, tenderness, and trophic and vasomotor disturbances may also be present in varying degree, depending, as a rule, on a low type of neuritis. In cases of total arm palsy, as in avulsion of the brachial plexus, there are often eye symptoms due to the loss of the ciliospinal fibers from the first dorsal nerve.

The **diagnosis** of the position and extent of the lesion is made from a consideration of the muscles paralyzed and a reference to the following table of the nerve supply of the muscles, and to the semidiagrammatic scheme of the brachial plexus (see Fig. 540):

MUSCLES MOVING SCAPULA AND ARM.*

Muscle.	Nerve Plexus Division.	Root Origin.
Trapezius	Spinal accessory	C. II to VI.
Rhomboideus	Spinal accessory	C. IV and V.
Levator angulæ scapulæ	Spinal accessory	C. III, IV, and V.
Serratus magnus	Posterior thoracic	C. V, VI.
Deltoid	Circumflex (posterior cord)	C. IV, V.
Supra- and infra-spinati	Suprascapular	C. IV, V.
Teres minor	Circumflex	C. V.
Subscapularis	Short subscapular	C. V, VI.
Latissimus dorsi	Long subscapular (posterior cord)	C. VII.
Pectoralis major	Anterior thoracic (outer and inner cords)	C. V, VI.
Teres major	Suprascapular (posterior cord)	C. VI, VII.
Muscles Moving Forearm.		
Triceps	Musculospiral (posterior cord)	C. VI, VII.
Brachialis anterior	Musculospiral and musculocutaneous (outer and posterior cords)	C. V, VI, VII.
Biceps	Musculocutaneous (outer and posterior cords)	C. V, VI, VII.
Brachioradialis (supinator longus)	Musculospiral (posterior cord)	C. V, VI, VII.
Supinator brevis	Musculospiral (posterior cord)	C. V.
Pronators (teres and quadratus)	Median (outer and inner cords)	C. VI, VII.
Muscles Moving the Hand.		
Flexors of Wrist.		
Flexor carpi ulnaris	Ulnar (inner cord)	C. VIII, D. I.
Flexor carpi radialis	Median (outer and inner cords)	C. VII, VIII.
Extensors of Wrist.		
Extensor carpi radialis longus, Extensor carpi radialis brevis, Extensor carpi ulnaris	Musculospiral (posterior cord)	C. VI, VII.
Extensors of Fingers.		
Extensor communis digitorum, Extensor indicis, Extensor minimi digiti	Musculospiral (posterior cord)	C. VI, VII.
Flexors of Fingers.		
Flexor sublimis	Median (inner and outer cord)	C. VII, VIII.
Flexor profundus	Median and ulnar (inner and outer cord)	C. VII, VIII, D. I.
Interossei and lumbricales	Ulnar (inner cord)	C. VIII, D. I.
Two outer lumbricales	Median (inner and outer cord)	C. VIII, D. I.

As shortly after the injury muscles are paralyzed whose nerve supply is only overstretched and not lacerated, it is necessary to test the electric reactions of the muscles or to wait a few months to determine the amount of permanent paralysis and the extent and position of the destructive

* After Clark, Taylor, and Prout.[65]

lesion. Electric reactions are often unsatisfactory in children. After a few months a thickening and induration of the nerve-roots may be pal-

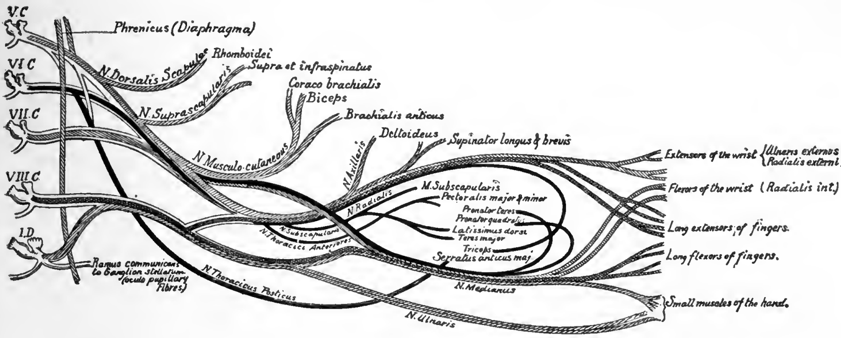


FIG. 540.—SEMIDIAGRAMMATIC SCHEME TO SHOW THE FORMATION OF THE BRACHIAL PLEXUS AND THE NERVE-SUPPLY TO THE MUSCLES OF THE UPPER EXTREMITY (Kocher).

pated at Erb's point, 2 cm. external to the sternomastoid and the same distance above the clavicle.

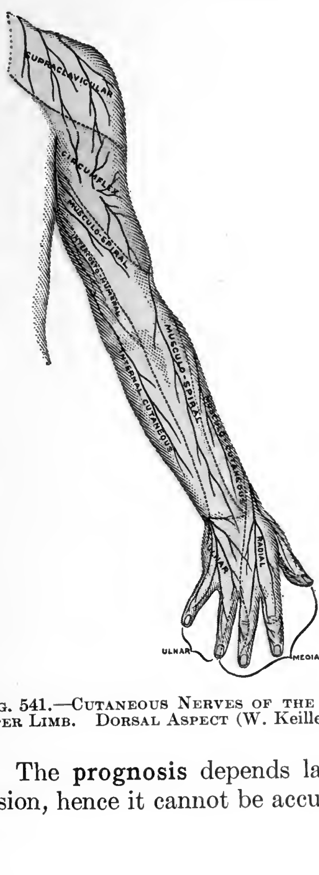


FIG. 541.—CUTANEOUS NERVES OF THE UPPER LIMB. DORSAL ASPECT (W. Keiller).

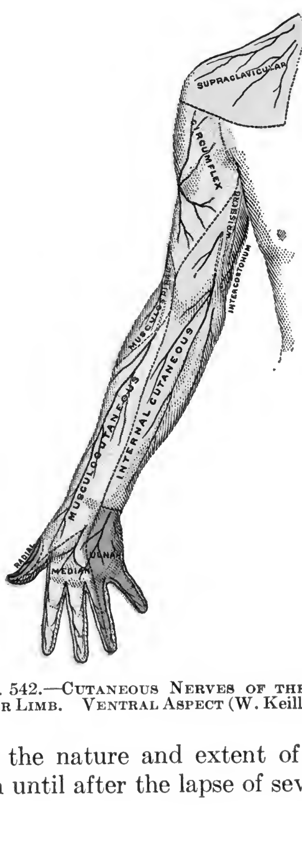


FIG. 542.—CUTANEOUS NERVES OF THE UPPER LIMB. VENTRAL ASPECT (W. Keiller).

The **prognosis** depends largely upon the nature and extent of the lesion, hence it cannot be accurately given until after the lapse of several months (six to ten). The mild cases will recover spontaneously and quite promptly; the more severe cases recover up to a certain point, which time alone can determine, but some paralysis persists when laceration of a nerve-root exists. In still more severe cases the arm remains completely paralyzed. When, after the injury, there is traumatic neuritis of the nerve-roots, the prognosis is bad: at least partial paralysis will persist. The electric reaction of the muscles helps us in the prognosis of the extent of permanent paralysis. The use of the proper treatment to assist in the repair of moderately damaged nerves, in the nutrition of muscles, and in the prevention of deformity, *i. e.*, massage, passive motion, electricity, and apparatus, if necessary, will favorably affect the prognosis.

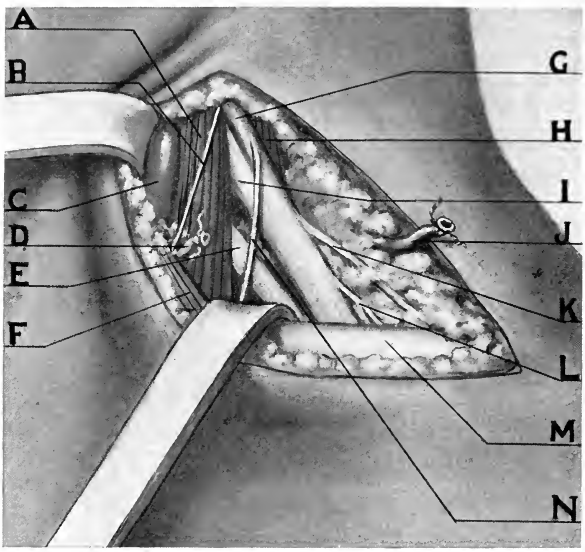


Fig. 543.—Dissection of the Operative Field in Brachial Birth Palsy (Clark, Taylor, and Prout).

A, Scalenus anticus muscle; B, phrenic nerve; C, internal jugular vein; D, transversalis colli artery, divided; E, VII cervical root; F, omohyoid muscle; G, V cervical root; H, scalenus medius muscle; I, VI cervical root; J, transversalis colli artery; K, suprascapular nerve; L, nerve to subclavian muscle; M, clavicle; N, nerve to scalenus anticus muscle.

The Treatment.—In mild cases nothing is required except that just mentioned, and in all cases, unless there is neuritis, this should be faithfully employed until recovery results or it becomes necessary to operate. When there is neuritis, complete rest in the normal position is demanded until inflammation has subsided. The only treatment for cases of permanent paralysis is the excision of the scar tissue replacing and surrounding the injured nerve and the suture of the freshened nerve-ends. The time at which to undertake this treatment is still a matter of dispute. Kennedy[69] advises early operation—in two to three months if the muscles give no response to the faradic current. If the muscles respond and continue to improve in response to the faradic current, he does not operate but expects spontaneous recovery. Taylor[65] advises delay for a year in most cases of brachial birth palsies. The advantages of this delay are a more definite localization of the lesion, larger size of the field of operation, and diminished danger from shock and hemorrhage.

The *incision* extends from the posterior border of the sternomastoid at the junction of its middle and lower thirds, to the junction of the middle and outer thirds of the clavicle through the skin, platysma, and deep fascia. The omohyoid muscle, exposed near the clavicle, with the suprascapular vessels beneath it, are retracted downward, or, if necessary, divided. Beneath the layer of fat at this level the deep fascia, usually thickened, covering the plexus is divided and dissected away from it. The injured portion of the nerve or nerves, determined beforehand from the paralysis, is felt to be thickened or indurated. This area is excised by a

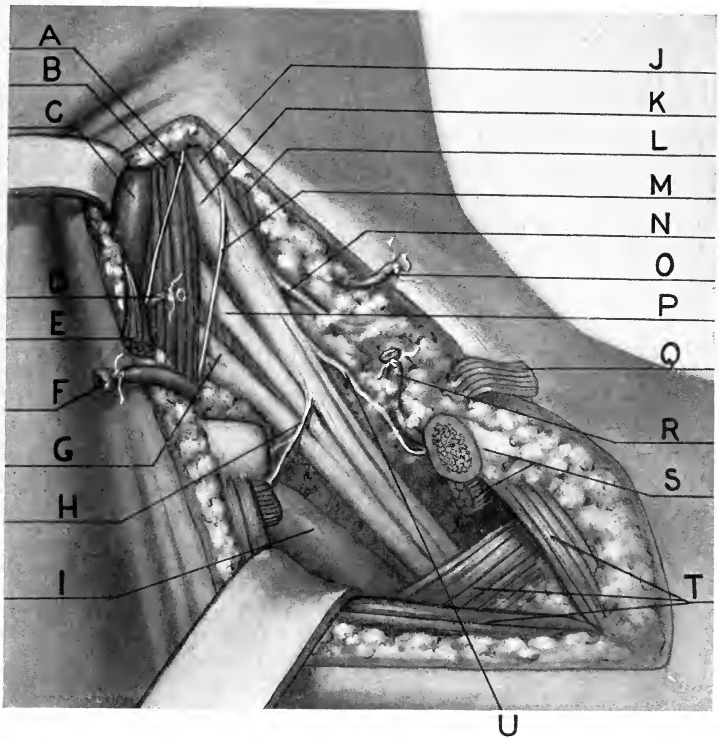


Fig. 544.—Dissection of the Operative Field in Brachial Birth Palsy (Clark, Taylor, and Prout).

A, Phrenic nerve; B, scalenus anticus muscle; C, internal jugular vein; D, transversalis colli artery; E, omohyoid muscle, divided; F, suprascapular artery, divided; G, VIII cervical and I dorsal roots; H, external anterior thoracic nerve; I, subclavian artery; J, V cervical root; K, VI cervical root; L, scalenus medius muscle; M, nerve to scalenus anticus muscle; N, suprascapular nerve; O, transversalis colli artery; P, VII cervical root; Q, omohyoid muscle, divided; R, suprascapular artery; S, clavicle and subclavius muscle, divided and retracted; T, deltoid, pectoralis minor, pectoralis major (muscles); U, nerve to subclavius muscle.

sharp scalpel through healthy nerve tissue and the ends sutured. (See Nerve-suture, p. 747.)

This incision suffices for the common type where the lesion is confined to the fifth or fifth and sixth nerve-roots and their junction. When, however, the lesion extends to the lower roots of the plexus or lies in the lower part of the plexus, the incision should be extended downward and the clavicle, subclavius muscle, and, if necessary, the pectoral muscles divided to give a better exposure. If thought best, the operation may be done in two stages to avoid too long an operation and too much shock. The clavicle is afterward sutured periosteally. An immobilizing dressing approximating the head and shoulder to relieve any tension on the plexus should be applied and this position maintained for two or three weeks. After-treatment by massage, electricity, and the use and education of the muscles is very important. The results of these operations have been very encouraging. The improvement is slow and continuous through a number of years.

One of the most common and interesting forms of brachial palsy are the **brachial birth palsies,** usually of the upper arm type, very rarely the total arm palsy. They may occur in either vertex or breech presentation, when traction is exerted and the head pulled away from the shoulder. The attitude is very characteristic in severe cases; the arm hangs limp by the side, as it cannot be abducted at the shoulder or flexed at the elbow, and, as it cannot be rotated out at the shoulder or supinated in the forearm, the whole arm is rotated in and the hand is pronated so that it looks backward and sometimes even outward. They should be operated on as described above. Kennedy[69] and A. S. Taylor[65] have each reported 7 operations with good results, and among them were cases ten and eleven years old.

Anesthesia paralysis of the brachial plexus[70] may involve all or part of the nerves of the plexus and is often complete; in six reported[71] cases it was bilateral. There is partial or complete sensory involvement. It occurs only after long operations when the arms are held above the head or forcibly abducted. Some return of function often occurs early, and total recovery is to be counted on, though it may take five or six months or even longer. The mechanism has been explained in different ways: (1) By pressure on the nerve-roots between the clavicle and the muscles over the cervical transverse processes. (2) By stretching the nerve-trunks over the head of the humerus. Combined with the latter mechanism there may be some forcible abduction of the head and neck to one side, as in case of vomiting.

Cervicobrachial neuralgia involves the branches of the brachial plexus and is relatively rare. It occurs oftener in women, and is due to the ordinary causes of neuralgia. The pain is unilateral, usually worse at night, and is increased by use or exposure. It is accompanied by paresthesia, often by anesthesia and vasomotor disturbances, and by trophic disturbances if there is neuritis. Painful points may be felt. It usually involves all the nerves of the plexus. If an isolated nerve is affected, it is generally the ulnar, next the musculospiral, and least often, the median. The prognosis is good if the neuralgia is functional and even if it is neuritic. It lasts about six weeks. The treatment is that for neuralgia elsewhere.

Injuries to single nerves about the shoulder-joint occasionally occur. They have been carefully reviewed by Bunts.[72]

The **circumflex nerve** is sometimes contused, compressed, overstretched, or more often lacerated in contusions and dislocations of the shoulder or during the reduction of the latter. The resulting paralysis and atrophy of the deltoid may be noticed directly after the injury, or not until the use of the arm is permitted. It is liable to be permanent in nearly two-thirds of the cases.

Treatment by massage, electricity, etc., is all that has been employed. Nerve resection and suture should be done when the reaction of degeneration shows non-conductivity of the nerve, as in such cases the nerve has probably been lacerated.

The **long or posterior thoracic nerve** is not uncommonly compressed or contused by heavy weights on the shoulder or by the contraction of the scaleni in excessive muscular strain. It may also be injured in operations on the axilla (breast operations). The resulting paralysis of the serratus magnus is seen in the altered position of the scapula, whose vertebral border is directed obliquely from above downward and inward, is approximated to the vertebral column, and is unduly prominent, especially at the inferior angle (winged scapula). In addition a high position of the scapula may be observed. The prognosis and treatment are the same as in the case of the circumflex nerve. Bunts[72] states that a suitable support to fix the scapula to the thorax is very helpful.

The **suprascapular nerve** is rarely injured alone. The diagnostic symptom is the depression of the two fossæ, due to atrophy of the spinati muscles. In addition, weakness in outward rotation is noticed. Resection and nerve suture would seem indicated in permanent paralyses of this nerve of traumatic origin.

The **musculospiral nerve** is more subject to injury than any of the nerves of the arm, owing to its close relation to the bone, as it winds around the humerus in the musculospiral groove. V. Bruns found its injury comprised 40 per cent. of nerve injuries complicating fractures, and was most frequent in fractures of the middle third of the humerus.

Etiology.—The common cause is fracture of the lower two-thirds of the humerus, especially when there is much displacement of the fragments. The lesion may occur at the time of the fracture (primary paralysis) by stretching or laceration over a displaced fragment or contusion between the fragments. Or it may not occur till later (secondary paralysis), from compression by callus or scar tissue against projecting fragments or within a bony canal. Actual loss of continuity of the nerve is rare.

Contusion not producing fracture,[73] pressure on the nerve during sleep or against the edge of an operating table or by crutches, and bullet and stab wounds[74] have also caused this paralysis.

Symptoms.—Its injury involves *musculospiral paralysis,* whose sensory limits are indicated in Figs. 541, 442, and whose motor palsy depends upon the level of the lesion. The point of injury is usually below the branches to the triceps and often below that to the brachioradialis, so that in the common form the supinator brevis and the extensors of the wrist, thumb, and first phalanges of the fingers are paralyzed, causing the characteristic "wrist-drop," due to inability to extend the hand and first phalanges. Atrophy of the paralyzed muscles soon follows. The anesthesia on the dorsum of the forearm and hand is variable in extent. Supination is generally lost or lessened, and extension of the elbow may be weakened.

There is the usual change in electric reactions. The symptoms may be noticed at once or shortly after the injury, or, more commonly, during the course of healing of the fracture, or even at a still later period. In all fractures of the shaft of the humerus the function of this nerve should be tested. Ollier[75] pressed the fragments together to determine whether the nerve was caught between them.

Prognosis.—Cases due to a simple contusion or compression, and those in which the cause, in the shape of a displaced fragment, has been removed, often go on to spontaneous recovery. In other cases the prognosis as to function is not good without operative treatment.

The *treatment* in primary paralysis is expectant at first, and consists of massage, douches, electricity, and gymnastics. In case of fracture of the humerus the displacement of the fragments should be carefully reduced and kept reduced. Fessler[76] lays great stress on avoiding outward bowing at the site of the fracture, even to the extent of producing some

FIG. 545.—WRIST-DROP, DUE TO PRESSURE PARALYSIS OF THE MUSCULOSPIRAL NERVE, EITHER THROUGH BEING INVOLVED IN A CALLUS OR CAUGHT BETWEEN FRAGMENTS IN A FRACTURE AT THE MIDDLE OF THE SHAFT OF THE HUMERUS; WHEREAS IN THIS CASE IT FOLLOWED TOO TIGHT AN APPLICATION OF AN ESMARCH CONSTRICTOR (Eisendrath).

inward bowing. In compound fractures with signs of severe injury of the nerve the opening should be enlarged and the nerve exposed for primary suture unless infection is thought probable, in which case the wound should be packed and the nerve suture delayed until the infection has cleared up. In simple fractures without evidence of the nerve being caught between the fragments await the consolidation of the fracture; in the mean time the paralysis is often cured or improved so that operation is unnecessary. In other cases, when the paralysis fails to disappear under the above treatment, and in all cases of secondary paralysis, the nerve should be exposed by an incision parallel to or crossing the course of the nerve at a very acute angle and extending well above and below the level of the injury. Above, the incision is carried along the posterior border of the deltoid insertion, below along the anterior border of the brachioradialis. If there is difficulty in finding the nerve, it should be sought above or below the seat of the lesion, where it is in its normal relations, and traced from there. All adhesions, scar tissue, callus, or bone surrounding, compressing, or stretching the nerve should be dissected away. If the nerve appears otherwise moderately normal, or even more or less sclerosed and shrunken, it may be simply stretched with a good result. If a segment of it appears on palpation markedly sclerosed and shrunken or enlarged, it is better to resect this part. In such cases, or when in complete section, the healthy ends are separated by a wide interval, the problem arises as to how to bring the ends together. This may often be accomplished by stretching the nerve in both directions before the ends are freshened. (For other expedients,[77,78] see Nerve Suture, p. 747.) To separate the nerve from the bone and prevent its reinvolvement in callus and adhesions, see p. 750.[4] Every precaution must be taken to secure primary union. The after-treatment is quite as important as the operation (p. 751). It is not always the fresh cases that furnish the best prognosis. Rinne[75] operated with success after three and one-half years,

Fig. 546.—Clawhand.
Griffin clutch of Duchenne (Fowler).

and many successful cases are reported in the second year after the injury. Suture of the musculospiral gives better results than suture of any other nerve of the arm.

The ulnar nerve supplies the flexor carpi ulnaris, the ulnar half of the flexor profundus digitorum, the muscles of the hypothenar eminence, the interossei, the inner two or three lumbricales, the adductor transversus pollicis, and the deep head of the flexor brevis pollicis.

In **ulnar paralysis** there is, therefore, inability to flex the proximal phalanges or to extend the last two (interossei), except in the thumb; the little finger can be moved but little, and the fingers cannot be abducted or adducted, except feebly. If the lesion is at or above the elbow, flexion and adduction of the wrist and flexion of the last three fingers are weakened. The affected muscles atrophy, and the unopposed antagonist muscles produce the so-called "clawhand," or "main en griffe," by hyperextension of the first phalanges and flexion of the last two. The area of cutaneous anesthesia is seen by reference to Figs. 541, 542, though the anesthetic area varies, owing to anastomoses and supplementary sensation.

Injury of the ulnar nerve may cause the above paralysis. It is the most common nerve injury of the arm next to that of the musculospiral, and occurs especially at the elbow and just above the wrist, in connection with fractures of the internal condyle, dislocations of the elbow, contusions, and wounds. After fractures of either condyle paralysis of the ulnar nerve may occur some time after the injury from the pressure of callus or from compression between the olecranon and the condyle,[79] the fixation of the former being lost by reason of the fracture. In such cases the elbow is usually in the position of cubitus valgus. The *diagnosis* is readily made from the distribution of the paralysis and the anesthesia and from the position of the hand.

Treatment.—If the nerve is severed by an open wound, primary suture is indicated. In other cases it may be impossible to distinguish between an injury that will undergo spontaneous repair and one that will be followed by persistent paralysis, except in the course of time. The electric reaction is here of service. If, after two weeks, there is complete reaction of degeneration, exposure and suture of the nerve are indicated. In other cases it is better to allow time for spontaneous recovery, keeping the affected muscles in a healthy condition by massage, passive motion, douches, and electricity. If paralysis persists, the nerve is to be exposed, freed from adhesions or pressure, stretched, or resected and sutured.

Dislocation of the ulnar nerve from the groove in which it lies between the olecranon and the internal condyle may be—(1) idiopathic or congenital or (2) due to trauma. When it has once occurred, it is likely to become recurrent. Cases of the first class are the most common, but rarely require operation, as the symptoms are not severe enough. The fixed position of the nerve in its groove is not so constant as commonly supposed. Haim,[80] among 350 persons examined, found a subluxation of the nerve in 20 per cent., and all the latter cases showed a marked cubitus valgus. M. Cohn[79] states that in 25 per cent. of all persons the nerve leaves its groove in flexion of the elbow. This condition occurs especially in those with marked cubitus valgus, as in flexion the forearm deviates more than normally to the inner side. In addition the groove may be more shallow, the overlying and restraining fibrous bands less developed, and the internal condyle smaller than normal. The latter condition may perhaps be due to malunion of a fracture.

Traumatic cases are most often due to a fall on the flexed elbow,[80] with or without fracture of the internal condyle. It has also been caused by violent exertion with a flexed elbow, and Poucet[81] records one case due to violent extension of the elbow. It is probable that the restraining fibrous bands overlying it (the so-called arcuate ligament) first give way,[82] allowing the nerve to slip over the epicondyle. The nerve is often enlarged at the elbow.[83]

The *symptoms* are darting pain and paresthesia in the course of the ulnar nerve when it slips over the condyle as the elbow is flexed. In 20 per cent. of the cases[80] there are no symptoms. The *diagnosis* is easy.

The nerve is felt as a movable cord and may be pushed over the internal condyle.

Treatment.—If a traumatic case is seen at once after the injury, it would be proper to employ rest in the extended position with a small pad over the ulnar groove in the hope that the torn overlying fibrous tissue would heal. When the condition is recurrent and produces symptoms, the nerve should be exposed, its groove deepened, and an arcuate ligament provided to retain it by suturing a portion of the fascia of the triceps or even of the periosteum of the groove over it. If a low grade of neuritis exists from its oft-recurring displacement, the nerve should be stretched before it is fixed. Resection is not advisable.

The median nerve supplies all the muscles of the flexor side of the forearm and hand not supplied by the ulnar nerve.

Paralysis of the median nerve causes loss of flexion of the second phalanges of all fingers, and of the third phalanges of the forefinger and middle finger, loss of flexion, abduction, and opposition of the thumb, so that the latter lies in extension adducted against the forefinger, as in the so-called "ape hand." Pronation of the forearm is lost and flexion of the wrist is weak. If the injury is just above the wrist, only the muscles of the thenar eminence and the lumbricales are affected. In time the affected muscles suffer atrophy. Sensation is lost in the area shown in Figs. 541, 542, though this varies to some extent. **Injury** to the median nerve is most commonly due to wounds of the lower half of the forearm.[84, 85] The *treatment* is similar to that of injury of the ulnar nerve.

The several nerves of the arm may be unequally paralyzed after poliomyelitis anterior, thus affording opportunities for nerve anastomosis to cure the paralysis.

Intercostal Nerves.—Injuries of the intercostal nerves, due to fracture of the ribs, stab and bullet wounds, are not of great surgical interest except is so far as they may be a cause of neuralgia or neuritis.

Intercostal neuralgia is a very common form of neuralgia which occurs most often in women and in middle life. Aside from the usual causes of neuralgia, it may be due to pressure on the nerves in caries or tumors of the ribs or vertebræ. The *symptoms* are usually unilateral, and one or several nerves are involved. The sharp stabbing pains are not much increased by respiration, as is the pain of pleurodynia. There are tender points, especially over the points of exit of the lateral branches. The sixth to the tenth nerves on the left side are the ones most often involved. Though it usually runs its course in two to six weeks, it may be very obstinate and last months or years.

Treatment.—For such obstinate cases Nussbaum has stretched, Schede and others have resected or avulsed by the Thiersch method, the affected nerves. To expose a number of nerves, which, as a rule, are affected, an incision is made 5 cm. from and parallel with the median line. After exposing the intercostal spaces the external intercostal muscles are divided near the lower border of the ribs, and the nerve, lying below the vessels, is separated from them and resected or stretched central to its bifurcation. Apart from this, unless there is some cause for the neuralgia which can be relieved by operation, the treatment is medical.

The Sciatic Nerve.—Division of this nerve is comparatively rare. Although the nerve lies behind the head of the femur, Stimson[87] found only two cases reported in which it was so stretched by a dislocation or its reduction as to produce symptoms. Paralysis of the sciatic involves all the muscles below the knee and causes a peculiar gait, as the hip muscles are used to throw the leg forward at each step. Debersaques[88] reports the excision of 12 cm. of the nerve in the removal of a large sarcoma and the suture of the nerve by a nerve plastic operation with a fair result. A few moderately successful cases of suture of the sciatic nerve are reported. The treatment of injuries of the sciatic does not differ from that of similar injuries of nerves elsewhere. (For neuritis and neuralgia of the sciatic nerve see Sciatica.)

The external popliteal or peroneal nerve, from its position winding around the fibula below its head, is more subject to injury than the internal popliteal and its branches. Its paralysis may be due to division of the outer hamstring tendon in tenotomy; to pressure between the fibula and the edge of the operating table or other hard object, or by a tight plaster splint or adhesive plaster dressing; or to contusions at the same point. The anterior tibial has been injured in fracture of the bones of the leg. *Peroneal palsy* involves the peronei, the dorsal flexors of the ankle, and the extensors of the toes, causing the characteristic "drop-foot."

The *treatment* is the same as that of similar injuries of nerves in general. As the anterior tibial group of muscles supplied by this nerve are those which most often remain paretic after anterior poliomyelitis, opportunity is afforded to treat this condition by nerve anastomosis between the affected external and the intact internal popliteal nerves.

The cervical sympathetic consists of three ganglia with connecting filaments or cords and branches to and from it. It lies behind the carotid sheath and to the inner side of the vagus.

Physiology.—*Irritation* of the sympathetic in various parts of the neck causes dilatation of the iris, widening of the palpebral fissure, contraction of the blood-vessels of the head, face, and neck,—often with increased perspiration,—and tachycardia. *Paralysis,* as after resection of the ganglia, causes contraction of the pupil; narrowing of the palpebral fissure from ptosis; decrease of ocular tension; recession of the eyeball; congestion of the conjunctiva, face, head, and neck, with increase of tears, of nasal mucus, of saliva, and sometimes of perspiration (often anidrosis), and decrease in the pulse-rate. Of these symptoms, the ptosis is permanent and perhaps also the decrease in pulse-rate, if previously rapid; the others are transient and disappear in a variable time. The contracted pupil has sometimes remained for a long time.

Based in part upon the above facts, but largely upon hypothetical grounds, the operation of sympathectomy, in which the superior, the upper two, or all three ganglia on one or both sides are removed, has been quite extensively practised for a number of unrelated conditions, especially glaucoma, exophthalmic goitre, epilepsy, and tic douloureux.

For **glaucoma** the superior ganglion only is removed, as the branches to the eye are given off from this. After removal of this ganglion decrease of intra-ocular tension has often been observed, but it is neither constant nor permanent. In spite of the weakness of the theoretic basis of the operation many cases have been cured or relieved that had resisted other forms of treatment. The results vary in the different forms of glaucoma. According to Wilder's statistics,[89] the results are best in acute, subacute, and simple glaucoma, and if iridectomy fails in the first two forms and miotics in the third, the removal of the superior ganglion is safe, justifiable, and to be recommended.

In **exophthalmic goiter** the thyroid hypersecretion is assumed by Jonnesco, Jaboulay, and others to be due to hyperemia of the organ, but the operation of sympathectomy they advocate causes a hyperemia, at least temporary, of the area supplied by the cervical sympathetic, so that hypothesis is here at variance with anatomic and clinical observations. It is not claimed[90] that the cervical sympathetic is the primary cause of the trouble, but that it is the connecting link between it and the organs secondarily affected—eye, thyroid, and heart. To interrupt all these links the bilateral removal of all these ganglia is, therefore, the logical operation. As to the results, Rehn[91] found the mortality somewhat less after sympathectomy than after partial thyroidectomy, but the percentage of cures is about half and the percentage of cases improved about double in sympathectomy as compared with thyroidectomy. The exophthalmos is the symptom most constantly affected, the tachycardia the next. It has been found that sympathectomy does not assure freedom from the occurrence of post-operative acute thyroidism, and it cannot readily be done under local anesthesia. I have had one death under anesthesia during this operation.

For **epilepsy** Jonnesco[92] describes the object of the operation to be the converting of cerebral anemia into hyperemia, thus improving the nutrition of the brain, also the cutting off of reflex impulses from the viscera to the brain. For this purpose it is necessary to remove both the superior and the inferior ganglia, the one sending vasomotor branches along the carotid, the other along the vertebral, artery. As the hyperemia of the face after sympathectomy is transient, there is no reason for supposing that that of the brain would be permanent. The results have not been particularly encouraging. Winter[93] found among 122 cases operated that 6 per cent. remained well more than three years, 17 per cent. were well but had not passed the three-year period, and in 54.9 per cent. there was no result. Jaboulay[95] noticed that there was a strong hysteric element in cases in which there was improvement, and concluded that the operation should be abandoned.[96]

Tic douloureux is another condition for which sympathectomy has been tried without very good results. The rationale of the operation is apparently the production of hyperemia, to counteract the anemia frequently present. Here, too, the transient character of the hyperemia is not favorable to the hypothesis.

Resection of the Cervical Sympathetic Ganglia.—The shoulders are elevated and the chin is extended and turned toward the opposite side. To expose all three ganglia the incision posterior to the sternomastoid from the mastoid to the clavicle is preferable. To expose the superior ganglia alone some prefer the upper three inches of this incision, others an incision along the anterior border of the muscle. In the posterior incision it is wise to split the muscle near its posterior border, otherwise the deep fascia is divided along the border of the muscle. Retracting the edges of the split muscle or the divided fascia one looks for the branch of the accessorius to the trapezius in order to avoid it. After dividing the deep fascia beneath the muscle in the line of the incision the sympathetic is reached by blunt dissection. Retract the muscle and the vascular packet inward and forward, and feel for and expose the anterior surface of the vertebral column covered by the prevertebral muscles. Look for the nerve in front of this, in a special aponeurotic sheath; if not found, it may have adhered to the back of the retracted vascular packet. To make its identity sure follow it up to the fusiform, reddish-gray, superior ganglion, 1 to 1½ inches long, in front of the transverse processes of the second and third cervical vertebræ. Isolate the ganglion by blunt dissection from below upward, dividing its branches as reached, and divide or tear the trunk which leads from its upper end. Follow down the nerve where first exposed to the inferior thyroid artery which it surrounds, and in front of which lies the small middle ganglion. In exophthalmic goiter it is well to ligate the artery; in other cases with traction on the nerve they may be separated by blunt dissection. Follow the cord or cords from this to the semilunar inferior ganglion, which usually lies internal and adherent to the vertebral artery, over the neck and head of the first rib, just above the pleura and between the longus colli and scalenus anterior muscles. Retract the latter muscle with the vertebral vessels and the thyroid axis downward and outward; the sternomastoid and carotid sheath inward and forward. After exposing the ganglion by dividing any overlying tissue, grasp it and free it from the vertebral artery, the rib, and spine, divide its connecting fibers, and remove it. The removal of this ganglion is the difficult part of the operation, but Balacescu[90] claims that it is not difficult if one knows its position well and protects the vertebral, carotid, and jugular vessels with Jonnesco's retractors. The pleura has not been injured in a series of 130 operations.[90] Suture with deep and cutaneous sutures to completely close the wound. The other side may be done at the same time or subsequently. Some operators open the carotid sheath to assure themselves of the position of the vagus.

OPERATION ON NERVES.

Neurolysis—the "loosening of nerves."

Indications.—This operation is called for to free an otherwise comparatively healthy nerve from cicatricial tissue, adhesions, callus, interposition between bony fragments, or imprisonment in an osseous or osseo-aponeurotic canal which, by pressure, cause paralysis, neuralgia, or neuritis. It is required especially in the musculospiral nerve, but may be required in the case of any nerve.

The **technic** consists—(1) in the exposure of the nerve. In order to avoid injury to the nerve embedded in the compressing tissue it should be exposed both above and below the site of the lesion. (2) The nerve is then freed from either end by careful dissection and all scar tissue removed. If the width of this tissue is only slight, the nerve may often be safely exposed and freed from one end. (3) After freeing the nerve it is often stretched, if the compression has been of long standing. Stretching alone may be sufficient to free the nerve from adhesions, which in case of the sciatic nerve are not infrequently the cause of the sciatica. In some cases where the nerve sheath is much thickened for a distance the latter is to be divided longitudinally, otherwise the nerve-fibers will not be relieved from pressure. (4) To prevent the reforming of adhesions, etc., the nerve should be wrapped in Cargile membrane, fascia, muscle, etc.,[96a] and where a rough surface of bone remains after the operation, muscle tissue should be interposed or the nerve embedded in muscle. The most important factor to prevent the reforming of adhesions is perfect asepsis of the wound, an essential in all nerve operations. (5) After-treatment. Rest until the wound has healed, then massage, passive and active motion, douches, and electricity to hasten the functional recovery. The latter is very rapid in many cases requiring neurolysis, unless, through neglect, the condition has lasted a long time.

Nerve Suture or Neurorrhaphy.—The observations of Mitchell, Morehouse, Keen, and others proved that, without suture, recovery *may* follow extensive injuries to nerves. Hüter showed that this could occur after $1\frac{3}{4}$ inches of the nerve had been removed, and Horsley[33] has seen an interval of $1\frac{1}{4}$ inches bridged over. Such instances are rare exceptions; the ordinary result without suture is paralysis, owing to scar tissue intervening between the ends of the nerve.

Indications.—*Primary suture,* or suture at the time of division, is indicated in wounds which sever nerve-trunks or where a nerve is divided in the course of an operation for the removal of a tumor involving the nerve.

The indication is very plain when the divided nerve is exposed at the time of the injury, but when it is lacerated subcutaneously, it is better to wait long enough to determine from the symptoms and the electric reactions whether the nerve is hopelessly paralyzed or will largely recover its function, and then do a secondary suture if necessary, for there is no way of determining at once the extent of the nerve injury except by exposure.

Secondary suture includes all those cases where the nerve is sutured subsequent to the time of the injury so as to require freshening of the ends before suture. It is indicated where primary suture has failed or where the symptoms indicate loss of conduction of the nerve and the ends are found separated or embedded in scar tissue, or a certain length of the nerve is replaced by scar tissue. If a wound in which a nerve was divided has healed by primary union, we should give it a fairly long time to show signs of regeneration—eighteen months, according to Horsley.

The *technic* of nerve suture consists—(1) in the exposure of the nerve.

In fresh open wounds its topographic relations lead to its position, though, owing to retraction of the nerve-ends, the wound, which is usually transverse, may require strong retraction or even longitudinal incision. In secondary suture the conditions may be much the same as described in neurolysis, so that the nerve, embedded in scar tissue, should be exposed from both ends. The central end is often readily found because of its terminal bulbous enlargement; the distal end may occasionally be somewhat bulbous; more frequently it is shrunken and tapering. Occasionally electricity applied to a nerve stump will help to determine or verify what trunk or branch it is.[97] (2) The ends, in case of secondary suture, should be freed from all adhesions and surrounding scar tissue, and the latter should be entirely removed. (3) Approximation of the ends. This gives no trouble in simple incised wounds without loss of substance, as the ends readily come together. But when they are widely separated from long-standing retraction or from loss of substance involved in the removal of a tumor or a cicatricial or diseased part of a nerve, it may be a difficult matter. Our chief reliance is in stretching of the nerve, both centrally and peripherally. This may enable us to overcome an interval of 3 cm. or possibly more. The stretching should be done by grasping the cicatricial ends with gauze before the ends are freshened for suture.

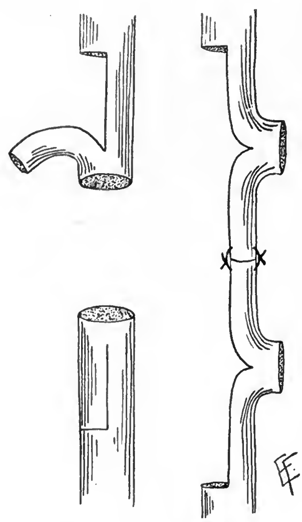


FIG. 547.—NEUROPLASTY.
Union by splitting both ends of nerve and uniting split ends end to end (Bickham).

Failing to bridge the gap by stretching there are several methods of bridging the defect to choose from.[98] (*a*) *Nerve transplantation* or suturing in the gap a suitable length of a nerve from some animal. This graft, according to Ballance and Stewart,[2] never heals in as a nerve, but the nerve elements become degenerated and absorbed, so that the graft acts only as a scaffold or framework for the growth of the nerve-fibers from either end. The results are not satisfactory; the improvement in some cases reported is open to question, and, according to Powers,[98] who collected 22 cases, the operation should be abandoned. (*b*) *Neuroplasty*, consisting in the detaching of a portion of the central or peripheral ends, or both, which is turned back and united by suture to the other end or the flap from that end (Fig. 547). Eleven cases of neuroplasty were collected by Powers and the results were satisfactory. (*c*) Intermediate suture, *suture à distance*, consists in bridging the defect with loops of catgut which also draw together the ends as near as possible. The results, with some notable exceptions, such as Gluck's and Ehrmann's cases, are not encouraging. (*d*) Another, but so far unsuccessful, method is tubulization or the implantation of the nerve-ends into the ends of an absorbable tube of bone or other material to favor the growing together of the nerve-ends by preventing the ingrowth of cicatricial tissue. (*e*) Resection of bone to allow the approximation and suture of the ends of the nerve. This has been successfully practised in the humerus by Keen,[77] Mikulicz,[78] Trendel-

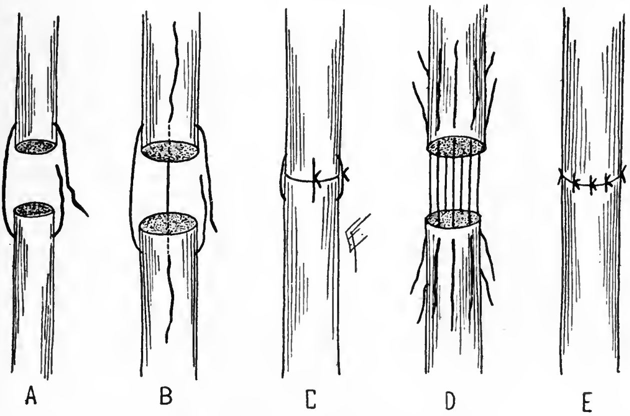


Fig. 548.—Methods of Nerve Suturing.
A, B, C, Sutures passing through entire thickness of nerve and sheath; D, E, sutures passing through nerve sheath only (Bickham).

enberg, Rixford,[99] and others to allow approximation of the musculospiral, and in the forearm by Löbker, in a case of loss of substance of the median and ulnar nerves. Under what conditions it is justifiable to resect the bone to bridge a gap in the nerves is a question that can be answered only in connection with the conditions present in a given case. As it allows nerve suture, which is preferable to any of the substitutes here mentioned, it has much to commend it in suitable cases. The amount of shortening of the bone must not be so great as to shorten the muscles so that they become useless. The results have been good. (*f*) Nerve anastomosis can almost always be done where the ends of the nerve cannot be approximated, and with the good results now obtained by this method in the treatment of various forms of paralysis, etc., it should always be considered where direct suture is not feasible. (See Nerve Anastomosis, p. 751.)

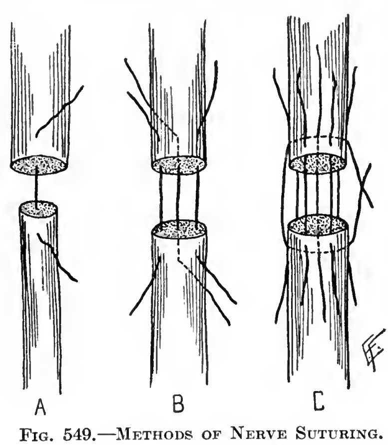


Fig. 549.—Methods of Nerve Suturing.
A, B, Sutures passing through sheath and part of nerve; C, sutures through sheath, reinforced by relaxation suture through entire nerve.

(4) Freshening the ends of the nerve in case of secondary suture should be done through healthy nerve tissue with a sharp knife—never by scissors.

(5) The suture may be *direct, i. e.,* through the nerve itself, or *perineural* (indirect), through the connective tissue of the nerve sheath. In the former an absorbable material like fine chromic gut is preferable, though silk has been successfully used. For perineural suture the finest silk is the best material.

In the direct suture some prefer two or more sutures through the periphery of the nerve, on the ground that less damage is done to the nerve-fibers than by a single central suture; others prefer a single suture, or two sutures crossing at right angles through the center of the nerve, and still others combine the two forms. The direct and perineural suture may also be combined. These sutures should be passed about a quarter of an inch from the end of the nerve. No bad ultimate effects are said to have been observed after direct suture.

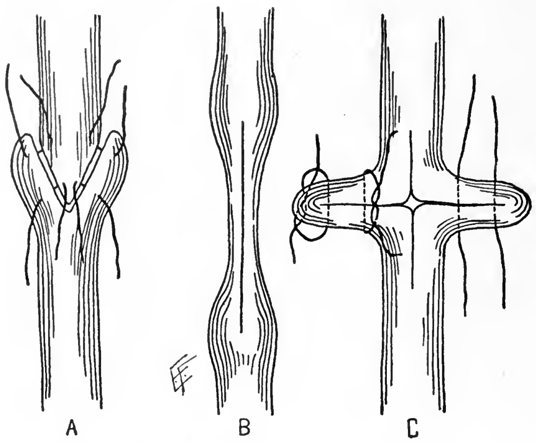


Fig. 550.—Methods of Nerve Suturing.

A, Suturing of beveled end between lips of split end; B, C, method of uniting sound upper and lower portions of nerve by splitting and suturing contracted portion (Bickham). These methods are shown only to be condemned.

In the perineural suture as few sutures as are necessary to secure accurate opposition should be used. It is advisable to pass all, or as many as possible, of the sutures before freshening the nerve-ends, so as to avoid handling the freshened ends of the nerve as much as possible. The form of suture and suture materials is of little importance as compared with that of an aseptic operation. Hence when pus is present or, from the conditions of the wound, is likely to occur, nerve suture should be deferred until asepsis is possible. The present tendency is to use perineural sutures of fine silk. After passing the sutures the opposed ends of the nerve are drawn into as accurate approximation as possible in tying the sutures.

(6) The prevention of adhesions and of the ingrowth of connective tissue. This is obtained most simply by wrapping Cargile membrane around the point of suture. Murphy[96a] recommends wrapping the nerve in fascia or muscle tissue. For the same purpose the use of arteries, fresh or hardened in formalin, has been tried and recommended by Foramitti,[101] tubes of gelatin hardened in formalin by Lotheissen,[102] and of absorbable magnesium by Payr.[103]

(7) Tension on the point of suture is to be carefully avoided during the process of healing, first by having previously stretched the nerve-ends and secondly by putting up and keeping the limb in a plaster splint in such a position of flexion or extension as will relax the sutured nerve.

(8) After-treatment. This is as important as any part of the treatment, and it should never be neglected, otherwise the functional result is less rapid and less complete. The limb is to be kept perfectly quiet for two to four weeks, after which use of the limb is allowed and massage, passive motion, and douches used. Electricity should be employed daily—at first the galvanic and later the faradic current. The main object of the after-treatment is to maintain or improve the nutrition of the muscles during repair and regeneration of the nerve. This treatment must be continued for a year or more.

The *results* of both primary and secondary nerve suture are excellent if primary union is secured, and are not materially different from one another. Thus among 84 cases of primary suture collected by Howell[32] 42 per cent. were successes and 40 per cent. improved; and of 80 cases of secondary suture, 38 per cent. were successes and 50 per cent. improved.

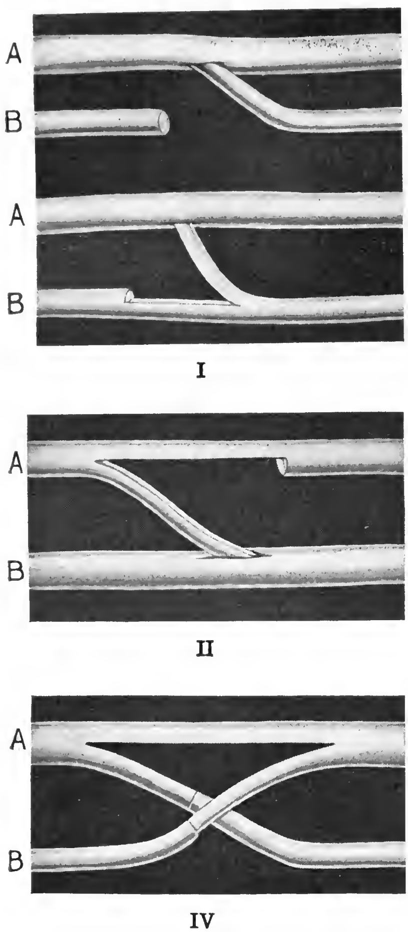
For the *prognosis* see p. 718. The length of time after an injury that secondary suture may be successfully undertaken depends mostly upon the condition of the affected muscles. So long as these are moderately well nourished or at least not completely degenerated, nerve suture is indicated. Secondary suture after nine years (Jessop), eleven years (Taylor[65]), and fourteen years (Jacobson) has been successful. If a primary or secondary nerve suture is not successful, the operation should be carefully repeated. After a second failure the same rule holds or an anastomosis may be tried. Apart from the simpler nature of the operation, primary suture has the advantage over secondary suture in the condition of the muscles and joints which delays functional recovery in the latter to some extent.

Several forms of secondary suture have been described[104] in which the terminal neuroma bulb is retained, but all these methods are to be condemned, as the neurofibroma end-bulb contains too much connective tissue to serve well as a conducting nerve.

Nerve Anastomosis. Nerve Grafting.—When a nerve is cut, sutured, and regenerated, the peripheral fibers are not continuous with the same fibers of the central end, and hence with the same nerve-cells in the cord, as originally. Suturing a nerve as nearly as possible in its original position and after one end is rotated through 180 degrees gives the same result. Kennedy[105] demonstrated that if the nerves of a limb were divided and the central ends of the flexor nerves were sutured to the distal ends of the extensor nerve, and vice versâ, voluntary coördinate movements were established in the same time as is required for restoration of function after simple suture. Moreover, in most cases irritation of the cortical flexor center of the brain produced extension, and vice versâ. Upon the basis of these and similar facts we are justified in anastomosing a paralyzed nerve with a neighboring intact nerve with the expectation that the paralyzed muscles will regain their function unless they are too much degenerated.

Indications.—Any paralysis of a group of muscles supplied by a nerve or nerves, provided there exists a neighboring intact motor or mixed nerve, turnishes an indication. This is exemplified in persistent facial paralysis, in palsies following acute anterior poliomyelitis, in injuries of or operations on nerves with loss of substance preventing apposition and suture. The paralysis of poliomyelitis is often confined to a single group of muscles, especially to those supplied by the anterior tibial (or the entire peroneal) in the lower extremity, and to those supplied by the musculospiral in the upper limb, thus affording opportunities for nerve anastomosis. The indications have been extended by Kennedy[105] to facial spasm, and by Spiller, Frazier, and Van Kaathoven[86] to athetosis.

Varieties of Anastomosis.—There are a number of methods or types of anastomosis which present advantages varying with the varying conditions presented in a given case.



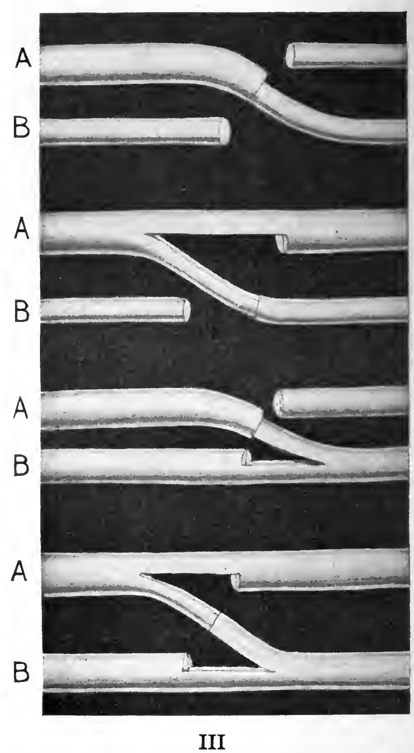


FIG. 551 —NERVE ANASTOMOSIS.

A, Intact nerve; B paralyzed nerve; I, lateral anastomosis (peripheral implantation); II, lateral anastomosis (central implantation); III, end-to-end anastomosis; IV, end-to-end anastomosis of both central and peripheral ends.

I. Lateral anastomosis—(*a*) of the entire peripheral end of the paralyzed nerve, or (*b*) of a large segment with a peripheral base split off from it (if not absolutely paralyzed) into a longitudinal slit or a niche in a neighboring intact motor or mixed nerve (peripheral implantation) (Fig. 551, I).

II. Lateral anastomosis of the peripheral end of a segment with a central base split off from an intact motor or mixed nerve into a longitudinal slit or a niche in the paralyzed nerve (central implantation) (Fig. 551, II).

III. End-to-end anastomosis of the peripheral end of the paralyzed nerve or a large segment split off from it with the central end of an intact nerve or a segment with a central base split off from it.

In any of these cases the central end of the affected nerve may also be implanted laterally into the intact nerve. This is especially desirable in case of loss of substance when the central end of the affected nerve is still active. In place of this we may proceed as follows:

IV. End-to-end anastomosis of both central and peripheral ends of the affected nerve into the opposite ends of segments split off from the intact nerve. This is preferable to Kilvington's [106] recommendation to divide both nerves and join all four ends, end to end, which is unwise, as there is a certain percentage of failures after nerve suture.

In certain cases, as when a single muscle is paralyzed, all that is necessary is—V, the lateral anastomosis of one or more muscular branches of the paralyzed into the intact nerve.

As there are a certain number of failures in nerve suture and anastomosis, that method is to be preferred which offers a good prospect of success without the risk of aggravating the paralysis. The peripheral implantation method (I) is most frequently applicable and harmless, and should be resorted to if the intact nerve is large and of equal or greater importance than the paralyzed nerve. If the latter contains no intact sensitive fibers, the entire nerve is to be used, otherwise a split-off segment. The central implantation method (II) may be used if the intact nerve is of less value than the paralyzed one, especially if it is a motor nerve, like the accessorius or obturator, the cessation of whose function would not be a great loss. In such cases III is also applicable, especially with the accessorius. As the fibers that go to any branch are scattered throughout the trunk until just above the point of branching, a partial division, say of a third, of the nerve, does not cause complete paralysis of any one branch, nor does it produce a corresponding degree of paralysis of the whole nerve.[31] Hence the splitting off of a segment from the intact nerve, as in II, III, and IV, does not entail much if any loss of function of that nerve, even in case of failure. Thus Hackenbruch,[46] after employing two-thirds of the accessorius for a central implantation lateral anastomosis (II) with the facial, states that the accessory muscle group had suffered only to a slight extent. Hence the transverse niche, involving one-fourth to one-half the diameter of the nerve, which Murphy[96a] prefers to the longitudinal slit in I and II, does not seriously paralyze the intact nerve. Those like Hackenbruch[107] who believe in the central theory of regeneration prefer to employ a segment split from the intact nerve. Although the regeneration of a paralyzed nerve requires the union of its axis-cylinders with those of the intact nerve and this requires the division of a considerable number of axis-cylinders of both nerves and the bringing of their cut ends together, yet the central ends of each of the divided axis-cylinders of the intact nerve divide into two or three branches so that the lateral implantation, as in I, appears from the satisfactory clinical results to comply sufficiently with these requirements. Although, theoretically, the more of the axis-cylinders divided, the more are provided for the regeneration of the affected nerve, the longitudinal slit divides a sufficient number of axis-cylinders for practical purposes, and a large segment or complete section of the intact nerve is found unnecessary, though a transverse niche is preferred by some.[96a]

Technic.—After exposure of the paralyzed nerve and the neighboring intact nerve they should be subjected to as little traumatism as possible. Hence handling with forceps is to be avoided, and to this end perineural sutures should be introduced before section and a little above the point where section is to be made. When a segment is to be split off from a nerve, the sutures serve to steady the nerve in making the partial section and as tractors in splitting up the segment. In dividing the nerve a sharp knife and not a pair of scissors is to be used. If a transverse niche is employed, the end or segment from the other nerve is sutured end to end to the cut fibers on the proper side of the niche. The niche represents a segment which has not been split off. The rest of the technic is the same as that for suture, except the implantation in a lateral slit. The nerve to receive the graft, supported on a small blunt hook, is slit longitudinally for $\frac{1}{2}$ to 1 cm., depending on the size of the graft, by a narrow-bladed double-edged knife. The nerve or segment of the nerve to be grafted, with two sutures, on opposite sides, applied before section was made, is inserted and fastened into this slit by passing the sutures through each edge of the split nerve sheath. To facilitate the insertion of the nerve into the slit the former may be cut wedge-shaped. As the sutures are tightened the end of the nerve or nerve segment is tucked into and held snugly in the slit, and is slightly turned with a probe in the direction of the nerve-fibers with which it is to unite, to facilitate the union of the divided central and peripheral axis-cylinders by bringing them more opposed to one another. To close the slit in the sheath, and thereby prevent the end of the nerve from slipping out, one or more simple or mattress sutures are applied at the ends of the slit. Spitzy[108] passes the suture longitudinally through the nerve at that end of the slit toward which the graft is directed, in order to avoid injury to the nerve-fibers if passed transversely. This precaution applies only when the sutures are passed through the nerve itself. Here, as in simple nerve suture, the method of suture and the material used are not so important as perfect asepsis. Cargile membrane is wrapped around the point of anastomosis to prevent the ingrowth of connective tissue and the formation of dense adhesions. The fixed dressing, applied so as to relieve the nerves of tension, and the after-treatment are the same as after simple suture.

Anastomoses have been made between the facial, accessorius, and hypoglossal, between the several nerves of the arm, between the internal and external popliteal, between the anterior tibial and musculocutaneous, and Spitzy[109] has experimentally made the anastomosis between the obturator (anterior branch) and the anterior crural nerve.

The *results* are very encouraging, but the operation is of too recent date and too unsettled technic for percentage statistics to be of much value. Spitzy[108] states that the results in man show only about 50 per cent. of cures or improvements, but this record will doubtless be much improved.

Neurectasy or **nerve-stretching,** first employed by Billroth and Nussbaum, has been practised for chronic affections of the peripheral nerves, for neuralgias (especially sciatica), neuritis, facial spasm, and various results of chronic nerve disorders, such as varicose and perforating ulcers, trophic skin lesions, etc. It is also indicated in many cases after neurolysis, where the nerve has been long compressed, and to break up adhesions at a distance from the point exposed. It is very useful in nerve suture to help in the approximation of the ends without tension. Nerve-stretching is not adapted to trifacial neuralgia. It has taken the place of neurotomy or neurectomy in painful spasm of motor nerves. Stretching is employed in the neuralgias of mixed nerves, like the sciatic, where neurectomy is contra-indicated on account of the important motor functions.

Technic.—The nerve is exposed and isolated, wrapped with a couple of layers of gauze, and pulled vigorously in a central and peripheral direction with the thumb and index-finger until it has become plainly lengthened. Even in case of the sciatic, which requires a weight of 183 pounds to break it (Trombetta), the traction should not exceed 30 or 40 pounds. Another method of stretching enabling one to measure the traction force is sometimes used, *i. e.*, a band of several thicknesses of gauze passed around the nerve is attached to a spring balance scale and traction applied through the latter. The former method is the one more generally employed.

For results, method of action, varieties (wet and dry), etc., see Stretching of Nerves, p. 711, and Sciatica, p. 710.

Neurotomy.—The simple division of a nerve, formerly somewhat used in the treatment of neuralgia, is now abandoned, owing to the very transient nature of the relief and the certainty of recurrence.

Neurectomy or the excision of a portion of a nerve is employed for the relief of intractable neuralgia, especially that of the fifth nerve. It succeeds only when the neuralgia is of peripheral origin. Unless a considerable length, 4 cm., of the nerve can be excised, the relief is only temporary, owing to the strong tendency to repair, especially when the nerve occupies a bony canal. To prevent this repair along bony canals, the canal should be plugged at both ends with silver- or gold-foil, lead, or dental cement, or with a silver screw, as practised by C. H. Mayo.[110] In such cases the canal should not be entirely opened up. But even if the relief is only temporary, the operation is justifiable and indicated, for the period of freedom from pain may last many months or a year or two. Recurrence may occur without reunion of the nerve from the intact collateral branches or from an ascending neuritis of the remaining part of the nerve-trunk. Permanent cures are, therefore, rare after neurectomy. To secure permanent cure the operation should be done early, while the neuralgia still depends upon a peripheral lesion, and as much of the nerve as possible should be removed. For the latter purpose *Thiersch's method* of extraction of the entire diseased nerve-trunk, together with its peripheral branches, by twisting and traction, is to be recommended. Or the central end may be avulsed up to the Gasserian ganglion, in the case of branches of the fifth nerve, by violent traction. The proportion of permanent cures by these methods is greater than after simple neurectomy.

The **technic** of neurectomy consists of the exposure of the affected nerve for as long a distance as possible and the cutting out of the longest possible section. From 3½ to 5 cm., if possible, should be excised, as regeneration has been known to occur over a distance of 1¾ inches. The technic varies with the nerve or branch affected. (See Tic Douloureux.)

In *Thiersch's method,* after dividing the nerve, each end in turn is seized by a small forceps obliquely to its long axis and twisted. The nerve becomes wound about the forceps and twisted and pulled out even to the finer divisions of its peripheral branches and centrally to its foramen of exit.

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CHAPTER XXXIII.

TRAUMATIC NEURASTHENIA, TRAUMATIC HYSTERIA, AND TRAUMATIC INSANITY.

By F. X. Dercum, M.D.,

PHILADELPHIA.

A generation ago the various nervous symptoms presented by patients who had suffered from accident or injury were almost uniformly attributed to organic lesions of the nervous system. Gradually, however, it was recognized that in the larger number of cases these disturbances were purely functional in origin. Erichsen's view that the symptom-complex known as "railway spine" is due to a chronic meningomyelitis, and perhaps also to an involvement of the membranes at the base of the brain, has been long since abandoned. In this interpretation Erichsen did not stand alone, for similar explanations were vouchsafed by no less important neurologists than Leyden, Westphal, and Erb. However, first Moeli directed attention to the purely psychic nature of many of the symptoms, and later Oppenheim, Thomsen, Wilkes, Walton, and Putnam noted the frequency of anesthesias. The American writers, especially Walton, recognized the hysterical nature of the symptoms, a position which Oppenheim did not at first fully adopt, and it remained for Charcot definitely to establish that the great majority of the nervous symptoms met with in accident cases have no basis on anatomic change, but are purely functional in character. Oppenheim finally, in his monograph on the "Traumatic Neuroses," which constitutes a distinct landmark in the history of the subject, places the purely functional nature of the nervous disorders following accident beyond dispute. Numerous writers have since shown that the nervous symptoms present may not all be due to hysteria, but that there may also exist a neurasthenia; indeed, it may happen that the symptoms of neurasthenia alone are present. Because of the coexistence of neurasthenia and hysteria in the same patient we may with propriety speak of a hystero-neurasthenia, or we may make use of Oppenheim's term, the "traumatic neurosis." Entirely pure cases of neurasthenia or of hysteria are relatively infrequent; however, they do occur, and this necessitates a separate consideration of each of these affections.

TRAUMATIC NEURASTHENIA.

Neurasthenia is so widely diffused and possesses an etiology so complex that it becomes necessary to consider it in its special relations to trauma, and to note in what respects, if any, traumatic neurasthenia differs from neurasthenia which has its origin in other causes.

Etiology.—The causes of neurasthenia are multiple. Prominent among them are loss of sleep, overwork, overstrain, worry, and long-continued unphysiologic living. Shock and trauma are to be added to this category. It would appear, however, that the trauma producing neurasthenia usually embodies two factors: first, the actual physical shock or injury; and, secondly, the psychic shock or fright. In a large number of cases there can be no doubt that the psychic shock is the more potent of the two, but it is also true that in others the shock of gross physical injuries predominates. However, not infrequently the physical injury is insignificant, or indeed entirely absent, and no other inference can be drawn save that the psychic shock or fright is the sole cause.

A very common condition is one in which some actual physical injury, usually of minor importance, has been received, together with a certain amount of nervous shock. The physical injuries usually consist of bruises and abrasions—of wrenches and sprains of muscular and fibrous tissues. One of the more common conditions is a sprain of the back—a so-called "traumatic lumbago." The diagnosis of injury to the muscles or fibrous tissues of the back and limbs should, however, be made with great care, as hysteria frequently simulates these conditions. I have every now and then seen a neurasthenic backache or a hysterical hyperesthesia mistaken for a deep-seated injury of the back, just as Erichsen used to mistake these conditions for a meningomyelitis.

The distinction between the damage wrought by actual physical trauma or concussion and the result of the psychic shock or fright is most important. Not infrequently, as just pointed out, the intensity of the nervous symptoms is out of all proportion to the intensity of the physical trauma experienced. The overwhelming preponderance of the psychic element in the production of the nervous symptoms in such cases is apparent.

Symptomatology.—The symptoms of neurasthenia following a trauma are essentially the same as in neurasthenia due to other causes. There is, however, a distinct difference in the clinical picture presented, a difference which owes its existence to the special etiology. It will be wise for us, therefore, briefly to review the symptoms of neurasthenia in general, and to point out as we progress how far they are modified and influenced by the special etiology of trauma.

The picture presented by neurasthenia is that of ready exhaustibility of the nervous system. I have at various times characterized neurasthenia as the "fatigue neurosis," and yet just here it is important to lay stress upon the fact that a patient who is the victim of traumatic neurasthenia complains not so much of being tired as of being weak, and he interprets his sensations in terms of weakness, while a patient suffering from ordinary neurasthenia interprets his sensations in terms of chronic fatigue. When questioned, however, a patient suffering from traumatic neurasthenia will answer just as does the ordinary neurasthenic, that he is incapable of any but very slight exertion—that effort readily fatigues him and increases the various distressing sensations from which he suffers. The symptoms of neurasthenia are all of them characterized by this fact of weakness, together with another feature, namely, irritability—weakness and irritability going hand in hand. These two factors are abundantly illustrated by many of the symptoms of neurasthenia, as we shall presently see. To the symptoms which present these features in a characteristic degree I have applied the term primary or essential symptoms. Other symptoms, however, are also present which are secondary or adventitious in their nature and are in themselves indirect outgrowths of the neurasthenic state. To these I will direct attention as occasion arises.

For practical purposes it is convenient to consider the symptoms of neurasthenia under the following subdivisions: sensory, motor, psychic, and visceral.

Sensory Symptoms.—The sensory symptoms are both general and special. The general symptoms are those which the patient refers to his body as a whole, or which, even when localized, are somewhat diffused. To this group belongs the general feeling of exhaustion or of general fatigue. In cases of neurasthenia of average severity this feeling is always present. It is sometimes masked by other and more prominent local symptoms, but even under such circumstances it can be elicited by properly directed questions.

Headache is an exceedingly common feature of neurasthenia, both traumatic and non-traumatic. It may not, and usually does not, bear any relation to the special form of trauma. It is usually diffuse in character, but as a rule is especially referred to the back of the head or to the upper part of the back of the neck. Not infrequently it is widely diffused over the entire head and is merely accentuated in the occipital region. At other times, though less frequently, it is more pronounced in the frontal region.

Backache is another of the more common symptoms, even when the back has not itself been the seat of trauma. It is exceedingly important, of course, never to confound the backache of neurasthenia with the pain of a traumatic lumbago or other mechanical injury of the tissues of the back. True neurasthenic backache is preëminently a fatigue symptom and is usually mitigated or much relieved by lying down. It is dull and diffuse in character and often varies greatly in degree at various times in the same patient. It is not affected by motion of the trunk, though it is always, of course, made worse by fatigue.

Aching in the limbs is an unusual symptom in traumatic neurasthenia. When present it is described as dull and diffuse and may affect one or more limbs. Occasionally the aching is referred to a joint or, more accurately speaking, to the neighborhood of a joint, and in such instances care should be taken not to confound the case with one of rheumatism, true surgical disease, or with one of hysteria. The differential diagnosis will be considered later on.

There are present in the average case of traumatic neurasthenia other sensory disturbances much more definite in character. First among these is spinal tenderness. It is one of the most common features present in accident cases, even when the back itself has not been exposed to injury. In such patients we find that when we pass the finger over the spinous processes, exercising only superficial pressure, the patient acts as though the spine or the skin over it were tender. Not infrequently the patient complains of this condition previous to examination and refers it to a special region of the spine which, when examined, usually reveals no signs whatever of physical trauma. Sometimes, though rarely, the entire spine seems to be tender. Much more frequently, however, this tenderness is present only in certain small areas which appear to be situated immediately over the spinous processes. Further, they are found more frequently in certain situations than in others. Thus it is quite common to find such an area of tenderness over the seventh cervical spine, in the midscapular region, at the dorsolumbar juncture, over the midlumbar region, the sacrum, or the coccyx. The most frequent region in cases of traumatic neurasthenia is the spine at the dorsolumbar juncture; that is, we find, an area of superficial tenderness extending over the spines of the eleventh or twelfth thoracic vertebra and over the first, second, or third lumbar vertebra. At other times it extends somewhat farther up or somewhat farther down. Less commonly this tenderness is most marked in the midscapular region or over the cervical spine, and still less frequently is it most marked over the coccyx. The area that is painful is usually very small. If a localized spot, it can nearly always be covered by the tip of the finger, or if it is a strip of tenderness running over the spine, it is generally of a few fingers' width. At other times, though far less frequently, it appears to be more widely diffused, and is described as though it were deep-seated. Not infrequently also in severe cases the patient complains of a spontaneous pain,—a true neurasthenic ache,—which he describes as deep-seated, as though it involved the vertebræ themselves. He describes the pain as an aching, a soreness, or a burning. Spinal tenderness is present, of course, in varying degrees. It is sometimes so slight as to disappear or to be relieved by lying down. In other cases it is persistent and pronounced, and may constitute the principal feature of a given case and dominate all of the other symptoms It is this condition which was called by the older writers "spinal irritation," and which gave rise to the now obsolete expression, "railway spine." This condition was formerly grossly misunderstood and was almost always explained by injury to the spinal column or its contents, and yet, as we will presently see, adequate tests and methods of examinations fail absolutely to reveal any organic changes. As already stated, neurasthenic aching may also exist in a limb, but when regions of tenderness are noted over the limbs or in the neighborhood of joints, we should think, on the one hand, of hysteria and the various stigmata of this affection sought for, and, on the other, of actual surgical trauma. It is important also to bear in mind that the sensory disturbances of neurasthenia never assume the form of diminution or acutal loss of sensation. The existence, therefore, of an anesthesia or of a hyperesthesia at once negatives the diagnosis of a simple neurasthenia; a hysteria or an actual organic condition must in such case exist.

Motor Symptoms.—The patient not only complains of weakness, but weakness is usually readily demonstrable. It is a weakness which in a large majority of cases is founded upon actual feebleness of the muscles.

If the neurasthenia be at all pronounced, the patient will declare that he is unable to do his ordinary work, that he becomes readily fatigued, that he cannot walk far, that he cannot stand long, and that he frequently becomes so tired during the day that he is compelled to lie down. When tested by the dynamometer, it is not infrequently found that the grip is decidedly weak. In other cases, again, the grip may remain normal, but when tested repeatedly, it is noted that it becomes rapidly exhausted. In such instances the patient is able, by an effort, to simulate the normal condition, but the output of energy cannot be maintained, and incapacity for sustained muscular exertion soon becomes evident. The weakness of neurasthenia in traumatic as in ordinary cases is usually diffuse and general; sometimes it is accentuated in certain regions, such as the back; more rarely it is localized in a limb, but when localized, we should consider organic, hysterical, or other functional nervous disease, for true loss of power, actual paralysis, never occurs in neurasthenia. Sometimes a localized weakness is only apparent, the patient not moving a part freely because of pain produced. A familiar instance is seen in the difficulty which most patients suffering from traumatic lumbago experience when told to cross the knees. The movement is apt to be performed awkwardly and with effort, because the movement in some way increases the pain in the back.

Next to muscular weakness, tremor is noted. It is a symptom relatively infrequent in ordinary neurasthenia, and even when present in such cases is usually not pronounced. In traumatic cases, however, it is a very common symptom. It is present without emotional excitement, though such excitement may cause it to become more pronounced; it is usually more evident during the medical examination of the patient. This is especially true of the tremor of the hands. It is a rather fine tremor, frequently inconstant and irregular, but sometimes quite pronounced. Occasionally it involves the muscles of the trunk, especially of the back, and may be widely diffused. Here it is made notably worse by effort and is lessened by lying down. At other times spasmodic and irregularly recurring contractions of small bundles of muscle-fibers are observed, especially in the truncal muscles. These symptoms are usually associated with a clear history of direct trauma of the back. Sometimes a true traumatic lumbago coexists. The slight spasms or twitchings occasionally seen in the orbicularis palpebrarum, fibers of the frontalis, or elsewhere in the muscles of the expression, in cases of ordinary neurasthenia, are in my experience very rare in the traumatic form. It is in the hands and in the trunk that tremor in traumatic cases is most frequently met with, though it may, of course, be observed elsewhere.

When we come to test the knee-jerks, we find that they are, as a rule, exaggerated. This is true, indeed, of the tendon reactions as a whole. The skin reflexes, on the other hand, do not appear to be especially involved. Occasionally in very profound neurasthenia diminished tendon reaction is observed. On the whole, however, this modification is unusual. The tendons of the triceps and biceps and the various tendons at the wrist, like the patellar tendon, may reveal a plus reaction, though, as a rule, it is the patellar tendon which shows this reaction in a typical degree. Every now and then an ankle clonus is noted, but it is never so marked or so prolonged as we find it in organic disease of the cord. It is important to bear in mind that the reflexes never differ upon the two sides. It is important also to bear in mind, when traumatic neurasthenia is complicated by a traumatic lumbago, that while the knee-jerk may be exaggerated, the excursion of the leg may be quite limited; the leg is involuntarily restrained by the patient because the motion appears to add to or increase the pain in the back.

Special Senses.—*Disorders of Vision.*—In traumatic neurasthenia, as in ordinary neurasthenia, the special senses may also present symptoms. They reveal ready exhaustibility. It is very common for the patients to complain that they are unable to read for more than a few minutes at a time, that if they persist, the letters become blurred or indistinct, and that pain and other distressing sensations are induced. Not infrequently the statement is made that the patient cannot see, cannot read, cannot continuously perform any work which requires close and persistent use of the eyes. Headache, vertigo, tension of the eyeballs, and other symptoms may be complained of, such as difficulty of vision. The visual fatigue is made up of several elements; namely, ready exhaustibility of accommodation, ready cerebral exhaustibility, and ready exhaustibility of the retina. Of these, the exhaustibility of accommodation is perhaps the most important. The pupils are not infrequently large; sometimes markedly so. Indeed, dilatation of the pupils is at times a very striking feature, and is in keeping, other things being equal, with a grave degree of exhaustion.

Disturbances of hearing are rather infrequently noted in cases of neurasthenia of traumatic origin. Deafness, apart from organic injury or from hysteria, does not exist. The patient, however, not infrequently makes the statement that he does not hear properly or that there is something the matter with his ears. An examination of the ear is, as a rule, entirely negative, and yet the patient is probably in most instances honest in his statements. He frequently fails to hear because he is incapable of concentrating his attention properly, and that which is due to psychic fatigue is unintentionally referred to the organ of hearing. Now and then symptoms of auditory hyperesthesia are noted, and he suffers exquisitely from noises even when the latter are insignificant. Not infrequently various adventitious auditory symptoms exist, and these are often very distressing. They consist of various forms of tinnitus and are described as ringing, buzzing, roaring, throbbing, etc. At times they are referred to one ear more than to the other.

Disturbances of the sense of smell and taste are quite rare in traumatic neurasthenia, although every now and then noted in ordinary neurasthenia. Undue sensitiveness to odors—olfactory hyperesthesia—may exist. Statements are sometimes volunteered by the patient as regards the sense of taste which would lead us to infer that there is here also some hyperesthesia or perversion of function; however, traumatic cases rarely complain of disturbances of the sense of taste unless hysteria is present.

Psychic Symptoms.—These are especially important in traumatic cases. In true and undoubted neurasthenia of traumatic origin the same essential symptoms are present as in ordinary neurasthenia, though they are modified and influenced very frequently by an unfortunate attitude of mind, especially in cases which involve litigation. The essential psychic symptoms of neurasthenia present, as do the other symptoms, the picture of fatigue. There is a more or less marked diminution in the capacity for sustained intellectual effort. Just as the patient is incapable of long-continued physical labor, so is he incapable of long-continued mental labor, and persistent mental exertion sooner or later brings on symptoms of exhaustion. Painful sensations about the head, sensations of tightness or constriction, headache, and giddiness may make their appearance. Very frequently the attempt to do mental work brings on headache; at other times there is a very marked dislike and indisposition for intellectual labor. The patient finds that he must force himself to his work by an effort of will, but even under these circumstances the effort cannot be long maintained. Traumatic cases, like other cases of neurasthenia, frequently complain that they are losing their minds. "Loss of memory" is a very common expression. It is, however, obviously incorrect, as a brief examination discloses, for the patient almost invariably gives a circumstantial account of his case, omitting none of the essential details of the accident and of its immediate or remote consequences. There is a difficulty,—a genuine difficulty,—but this is really a lack of power to concentrate the attention, and this the patient mistakes for loss of memory. Such a patient may read an article in a newspaper or a page in a book and remember very little of it, but he does so because he has not been able to give his attention properly to the subject-matter while reading—has really never apprehended it or taken it in.

Upon the substratum of undoubted asthenia there is usually engrafted, especially in cases in which litigation is a factor, a belief that the symptoms are very grave in their character, and not infrequently the idea that he will never be well becomes lodged in the patient's mind. The constant brooding upon his condition often leads to a grossly exaggerated belief in the seriousness of his injuries. The constant repetition of symptoms to his counsel and to the physicians helps to fix and, as it were, to crystallize the symptoms. In keeping with this his habitual tone is that of mental depression, and as a necessary accompaniment there is present in many cases a marked nosophobia, which may in turn influence his ideas in regard to his various functions.

Some of the mental features frequently noted in neurasthenia of ordinary origin are much less frequently noted in traumatic neurasthenia. Thus, the attacks of spontaneous generalized fear every now and then met with in ordinary neurasthenia are quite uncommon in traumatic neurasthenia. This is also true of the various special forms of fear, the various phobias, with, however, one exception. In traumatic cases the patient not infrequently develops a special fear of the environment or circumstances under which the accident from which he suffered occurred. Thus one who has been in a railway collision not infrequently develops a fear of riding in a train or in a trolley-car, or if he has fallen from a height, develops a special fear of high places. The fear of riding in a train,—*siderodromophobia*, as it has been termed,—while it exists, is rarely met with in such degree as absolutely to incapacitate the patient from railway travel. It is, notwithstanding, a symptom from which patients complain, saying that the moment that they get on a train, or the moment the train is in motion, they become nervous, as though another accident were imminent.

In other respects traumatic neurasthenia resembles neurasthenia of the ordinary form. The patient frequently lacks the force and readiness of decision noted in health; hesitation, doubt, uncertainty, are frequently characteristics of his mental state, though this feature has never in my experience amounted to an actual *folie du doute*. In addition, a patient suffering from traumatic neurasthenia is, as a rule, irritable and cross. There is undoubtedly present, as in the ordinary neurasthenic, a pathologic defect of inhibition, but these defects do not manifest themselves in the form of irresistible impulses, imperative movements, imperative ideas, obsessions, and the like, such as we occasionally meet with in ordinary neurasthenia. Such symptoms, if at any time noted, always bespeak a preëxisting neuropathy and bear no relation to an accident. Further, they have never been noted by me in traumatic cases.

The disturbances of sleep in traumatic cases are very similar to or identical with those of ordinary neurasthenia. Insomnia is usually a more or less pronounced symptom. The ordinary history is that the patient falls asleep readily, but awakens at an early hour unrefreshed. Frequently he declares that he feels more tired in the morning than on going to bed. Very frequently the sleep disturbances are much more pronounced than this, the hours of sleep being comparatively short, the patient awakening at more or less frequent intervals during the night. It is important, of course, to bear in mind that patients usually grossly exaggerate the insomnia from which they suffer. Not infrequently the statement is made that he does not sleep at all, a statement which must, of course, be set down as a gross though perhaps unconscious exaggeration. Not infrequently also the sleep is attended by distressing dreams, dreams which rehearse the various experiences of the accident. Usually the dreams are of a painful character, sometimes horrible and terrifying. Quite frequently he awakens from such dreams in paroxysms of fright.

Visceral Symptoms.—Some of these are of considerable importance, especially the circulatory disturbances. Here symptoms are presented which, like those already noted, are indicative of weakness and deficient innervation. No symptom is more common, for instance, than coldness of the extremities. In traumatic neurasthenia of even moderate severity the hands and feet are usually cold and also damp. Quite frequently, too, the hands and feet are more or less livid. Sometimes the face is slightly dusky. In addition, disturbances in the character and frequency of the pulse and marked alterations of vasomotor tonus are noted. Palpitation of the heart is quite a frequent symptom and in some cases there is a persistent tachycardia. In others, again, tachycardia is brought on by slight physical exertion, such as walking upstairs, or it follows hurry or mental or physical excitement of any kind.

Not infrequently we note that the patient has a rather high color, the face being flushed, a fictitious appearance of health being thus simulated. At other times this flushing is paroxysmal. At times, too, loss of vasomotor tone may be noted in the larger blood-vessels. Occasionally aortic pulsation is noted, as in ordinary neurasthenia. At times, though more rarely, throbbing or pulsating sensations are referred to the limbs. Somewhat more frequently, pulsation or throbbing is referred to the head, and is then apt to be attended by slight giddiness.

Digestive disturbances are relatively infrequent and slightly pronounced in neurasthenia of traumatic origin. As is well known, ordinary neurasthenics commonly suffer more or less markedly from digestive disturbances, which are among the most distressing and most difficult of the manifold symptoms to treat. Digestive disturbances are, of course, noted in traumatic neurasthenia, but they are usually those of a rather mild atonic indigestion, attended by sensations of weight and distention in the epigastrium, by eructations of a tasteless gas, and by constipation. Distinct epigastric tenderness is rarely noted in traumatic neurasthenia, excluding, of course, cases in which there has been physical trauma of this region. It is a remarkable fact that in the ordinary neurasthenic the appetite is usually good. Indeed, in some cases it is exaggerated. Not infrequently the patient, after taking a normal amount of food, does not feel satisfied, or after the lapse of half an hour or an hour feels as though he has not had his meal. In traumatic neurasthenia a somewhat different picture is presented. A large number present no fluctuations of the appetite whatever. A somewhat smaller number say that they cannot eat as well as formerly, and a still smaller number assert that they have a decided loss of appetite. It is quite probable that the deficiency of appetite is associated with the habitually depressed mental state noted in these cases. The body-weight in traumatic neurasthenia usually indicates a loss—a loss frequently quite pronounced. This, of course, must stand in direct relation to the diminished appetite and the impaired power of digestion. Variations of the sense of thirst, such as are noted in ordinary neurasthenia, are but seldom noted in traumatic neurasthenia.

Marked disturbances of digestion, as already stated, are quite infrequent. However, the statement is every now and then made by the patient that he vomits his food. In such instances, of course, a careful study of test-meals or vomited matter should be made. In many cases a brief examination reveals the fact that vomiting bears no relation to the neurasthenia and that we have hysteria to deal with. In other cases, again, he states that he vomits blood. If the symptom is genuine, —if it can be verified,—simple or uncomplicated neurasthenia is excluded. The vomiting of blood occasionally met with in hysteria must here be borne in mind, as well as the relation of hemorrhage from the stomach to traumata—mechanical injuries, blows, and ulceration.

Disturbances of the Secretions.—As is well known in ordinary neurasthenia, all of the secretions may be affected. In neurasthenia there is a markedly deficient thirst, so that there is an insufficient ingestion of liquids. In keeping with this fact there is a diminution not only in the amount of the urine, of perspiration, and of the secretions of the stomach and intestines, but also a deficient secretion of saliva and consequent abnormal dryness of the mouth. In traumatic neurasthenia the secretions which manifest disturbances are especially the urine and the perspiration. As regards the urine, most patients present the symptoms of increased frequency of micturition, especially at night—an increased frequency of micturition which is associated with the disturbed sleep. It is quite common for cases of traumatic neurasthenia to make the statement that they awaken at frequent intervals during the night, and as soon as they awaken are obliged to empty the bladder, but the quantity of urine voided each time is usually small; only exceptionally is anything approaching a polyuria noted. It is worthy of note, also, that the frequency of micturition usually so marked at night is only exceptionally observed during the day. Examinations of the urine, excepting perhaps variations in the specific gravity, are usually negative. Neither chemical nor morphologic features are present.

The perspiration is, as a rule, increased; a diminished perspiration—that is, an unusually dry skin—is distinctly the exception in traumatic neurasthenia. The increased perspiration is especially marked about the hands and feet, in the axilla and groins, or about the head and neck. Exceptionally only is the tendency to sweating general.

It is known that in ordinary neurasthenia, transient glycosuria and transient albuminuria are noted in rare cases. In traumatic neurasthenia the occurrence is equally rare.

Sexual Disturbances.—It is a remarkable fact that a very large number of cases of traumatic neurasthenia complain of sexual disturbances. They are naturally noted more frequently among men than among women, though they not infrequently form an item in the claim for damages in both. As is well known, in ordinary neurasthenia there is not infrequently in the male a diminution of sexual desire, and as time goes on a more or less marked diminution of sexual power. At times, too, the sexual act is itself disturbed. The ejaculation may occur prematurely or may be unduly delayed, and the act may be accompanied by a diminution in the intensity of the sensations normally accompanying the act. The purely functional character of these disturbances, of course, should be borne in mind in giving an opinion. True impotence does not occur in traumatic neurasthenia so far as my experience goes. It is a remarkable fact that claims relating to the sexual functions are made by men with great frequency, the patient usually alleging that he is impotent. There is, of course, no adequate test which can be applied to such cases. Nothing but observation extending over some time, especially after litigation has ended, could be of value. However, in two instances in my experience, in which the claim of impotence had been made, the wives of the patients bore children before litigation had closed, and the time and circumstances permitted no other inference than the sexual competence of the husband. Further, we must also remember that when a traumatic lumbago is present this may reinforce the disinclination for sexual congress.

It is an exceedingly important and significant fact that other forms of sexual disturbances habitually noted in other neurasthenics do not exist in traumatic cases. I refer to the increased frequency of nocturnal seminal emissions so commonly noted in ordinary neurasthenia. How common and distressing this symptom is in many cases of ordinary neurasthenia is well known, and needs only to be mentioned. That it should be absent in true traumatic neurasthenia is very remarkable.

Women who have been the subject of trauma not infrequently complain of various distressing pelvic sensations. As a rule, as we shall presently see, these belong to the domain of hysteria, excluding, of course, those cases in which some real trauma of the pelvic organs has ensued—trauma is, however, in my experience, excessively rare. Female claimants, like male patients, also occasionally state, or their marital partners do for them,—and this is frequently added to as an element of damage,—that they no longer enjoy the sexual act, or that the sexual act is repulsive to them and that they no longer receive their husbands. In considering the value of these statements, we should be guided largely by our experience in ordinary neurasthenia. Women suffering from ordinary neurasthenia rarely, if ever, mention their sexual disturbances. Now and then nocturnal orgasms are mentioned; these are doubtless similar in nature to the corresponding symptoms observed in male neurasthenics. I have never known a case of traumatic neurasthenia to describe such an orgasm.

TRAUMATIC HYSTERIA.

Hysteria may arise in both sexes and at all ages. Like traumatic neurasthenia, traumatic hysteria is very rare in childhood, differing in this respect somewhat from ordinary hysteria. As in neurasthenia, the actual physical shock or injury may have been exceedingly slight, or indeed entirely absent, psychic shock or fright playing here the causative rôle. The symptoms that are present are those of hysteria, modified as in traumatic neurasthenia, by the special features and details of the accident and, when present, by the element of litigation.

Hysteria is a well-defined disease of the nervous system. Contrary to the opinions held for many generations, it is not a simulated disease; it is a genuine disease, many of the symptoms of which exist without the patient's knowledge. They occur in the male with about as much frequency as in the female. They do not bear any relation to any special visceral disturbances; least of all do they bear any relation to the pelvic organs. They are always distinguished by one important fact, namely, that they bear a distinct psychic impress; that is, an impress of a mental origin. This becomes apparent when we review the symptoms in detail.

The latter consist of sensory, motor, psychic, and visceral phenomena, definite in character, and which, when taken together, constitute a distinct and well-outlined clinical whole. The character of the symptoms is such as to suggest that there is primarily a disturbance of the cortical centers of the cerebrum. There are many facts, however, which indicate that the disturbance is by no means limited to this region. Notwithstanding, this fact of dominant cortical disturbance is of maximum importance and must never be lost sight of.

Symptoms.—As just stated, the symptoms of hysteria are made up of sensory, motor, psychic, and visceral elements.

Sensory Disturbances.—The sensory disturbances of hysteria present themselves, on the one hand, as losses of sensation more or less marked or as exaggerations or perversions of sensation on the other. The losses consist of anesthesia—that is, a total loss of sensation—or of hypesthesia, a partial loss or diminution of sensation. Hypesthesia is, on the whole, a much more common symptom than anesthesia. The sensory exaggerations manifest themselves especially as hyperesthesia, which hyperesthesia may be relatively slight or may be so pronounced as to be painful. Paresthesias may also be described by the patients, though they are comparatively infrequent. The sensory disturbances, as a rule, involve more or less definite areas, and it is at once noted that these areas bear no relation to spinal segmentation, on the one hand, or to the distribution of the peripheral nerves, on the other. A patient, for instance, may present an anesthesia of the hand investing the latter like a glove. Obviously it bears no relation to the facts of nervous anatomy. Similarly, anesthesia may be present in the foot and leg, and is then spoken of as a stocking-like anesthesia. Again, an anesthesia may involve merely a given portion of a limb; thus, it may extend from the wrist to the elbow, the parts above and parts below being entirely normal. Such an anesthesia is an instance of segmental anesthesia. On the other hand, irregular patches of anesthesia may be met with on the trunk, limbs, or rarely the face. Such an instance is spoken of as geometric or islet-like anesthesia. Not infrequently it involves the entire half of the body, constituting a hemianesthesia. In rare instances the entire body may be involved. In every case we are forced to refer the sensory disturbances to the cortex. Usually the sensory losses of hysteria involve all the forms of sensation. However, dissociated or partial sensory loss has in rare instances been observed; that is, loss of pain or temperature senses may exist with a preservation of the tactile sense. Close examination of such cases not infrequently reveals the fact that instead of there being a true dissociated loss, there is merely present a hypesthesia, the hypesthesia being most marked for the pain and temperature senses and less marked for the tactile sense.

As opposed to the anesthesias and hypesthesias of hysteria, we have hyperesthesias. These manifest themselves most frequently as isolated areas which are excessively sensitive to superficial pressure. Indeed, it is proper to speak of them as areas of painful hyperesthesia or hyperalgesia. They may be found upon any portion of the trunk or limbs, though there are certain favorite situations in which they are found most frequently. One of these is a small oval area over the ribs, just below the mammary gland; and, secondly, an oval area immediately above the groin. The first is technically spoken of as inflammatory tenderness and the second as inguinal tenderness. Much confusion was formerly caused by the mistaken term ovarian tenderness. The hyperesthesia, though painful, is extremely superficial and limited to the cutaneous surface. The non-involvement of deep structures can be demonstrated by very simple procedures. Thus, the patient having been placed in the position for gynecologic examination, the index-finger of the left hand is placed immediately upon the painful spot on the groin. If the index-finger of the right hand is inserted into the vagina and its tip brought immediately beneath the tip of the index-finger of the left hand, it can be demonstrated at once that the tenderness is situated exclusively in the abdominal wall, as slight pressure between the tips of the two fingers causes the patient to flinch and complain of pain. The finger within the pelvis can manipulate freely the uterus and adnexa without causing the patient to give any evidence of pain. It is a remarkable fact that the areas of painful tenderness are found more frequently upon the left side of the body than the right, and this is likewise true of other sensory disturbances. Painful areas may also exist in the form of isolated patches over the spine or to one or the other side of the spine below the inferior angle of the scapulæ. Not infrequently they are found in small patches upon the scalp. In the latter situation they are frequently so small that they can be covered by the finger-tip, and are frequently associated with spontaneous boring pain, and then give rise to the familiar picture of clavus hystericus. Both inframammary and inguinal tenderness, as also spinal tenderness, may be associated with spontaneous pain, which, like the clavus of the head, may assume a deep and penetrating character. Signs of visceral disease, as has already been stated, are always absent. This point is of especial importance when the area involves the nipple and adjacent portions of the mammary gland itself. Not infrequently serious injury of a breast is claimed when the symptoms are purely those of hysteria.

Occasionally patches of tenderness are found upon the various mucous membranes, especially on the mucous membrane of the vagina and of the rectum. In the case of the vagina, they are usually associated with the symptoms of vaginismus, and this fact should always be borne in mind in cases in which the claim is made that the wife has been incapacitated for the marital relation by the accident. The areas of hyperesthesia every now and then involve synovial surfaces, and in such instances may give rise to hysterical pain in a joint and may lead to the mistaken diagnosis of a surgical trauma of the joint. In my own experience, such a claim has been made in the instance of the elbow-joint, of the shoulder-joint, and of the knee-joint and hip-joint. It is of the utmost importance to bear in mind that in traumatic cases the sensory disturbances often bear a distinct relation to the special trauma received; thus, a blow upon the knee or a fall upon the elbow may determine the region in which pain, anesthesia, palsy, or contractures may make their appearance.

In hysteria the **special senses** may also reveal marked disturbances. Especially is this true of the eye. Here there may be a marked disturbance of the visual field. The most common form is that in which the peripheral portion of the retina is anesthetic, the patient then presenting a so-called hysterical contraction of the visual field. At times the curious condition, known as tubular vision, is present. Sometimes the blindness involves the entire retina, at other times, though rarely, a hemianopsia is present. As a rule, in the half of the retina in which the vision is still preserved, the field is also found contracted. Associated with this phenomenon we have the so-called reversal of the color fields. In health the retina is not equally sensitive to the various colors in all portions of the field; thus, violet is perceived in a relatively small central area, green in a somewhat larger area, red in a still larger area, yellow in a still larger, and blue in a still larger area. In hysteria the area in which blue is perceived becomes exceedingly contracted, so that it falls within the area in which red is still perceived; that is, instead of the largest field being that of blue perception, it is now that of red perception—blue perception being so far diminished as to fall inside the limits of the field for red. This symptom is merely one of anesthesia. The sensitiveness of the retina to violet diminishes or disappears first, then to green, then to blue, the red persisting until the last. It is of importance also to note that hysterical visual loss is, as a rule, most pronounced on the side in which hemianesthesia or other hysterical loss is found upon the general body surface. Among the rarer disturbances occasionally noted in traumatic cases is monocular diplopia—double vision with one eye.

Occasionally hysterical deafness is met with. Quite frequently this is an accompaniment of hysterical anesthesia. It is usually incomplete, the hearing being merely impaired. As a rule, in such cases, there is anesthesia of the external auditory meatus, frequently of the drum and at times of the auricle. Bone conduction is preserved. In traumatic cases patients repeatedly complain of deafness of one ear, and this, too, when a brief examination reveals that real deafness does not exist. The statement is probably honest in the majority of cases, but the question arises whether there may not be here some reduction or "contraction" of the sense of hearing corresponding or analogous to that which occurs in a contracted visual field. Occasionally also loss of the sense of taste of one-half of the tongue is noted or loss of the sense of smell upon one side. Hemiageusia and hemianosmia are not infrequently accompaniments of hemianesthesia, and are not infrequently met with in a typical degree in traumatic hysteria.

When we turn to the motor symptoms of hysteria, we may find local weakness or palsy, spasm of muscles, tremor, or incoördination. Occasionally also the patient suffers from convulsive seizures. The motor phenomena, like the sensory phenomena, are never referable to a lesion of the peripheral nerves or of the spinal cord. The motor disturbances may involve only a portion of a limb, as a foot or the hand, or it may involve corresponding portions of the body and thus give rise to a paraplegia. Not infrequently it involves one-half of the body, and then gives rise to a hemiplegia. Not infrequently a local hysterical palsy is associated with a contraction of the opposing muscle groups. At other times the palsy is flaccid in type. As a rule, the deep reflexes are increased, while the skin reflexes are abolished. Notably is this the case when the paralyzed limb is also the seat of anesthesia. Nutrition of the paralyzed muscles is usually unaffected, but in long persisting cases some diminution in size may be noted. It need hardly be added that the reaction of degeneration is never present.

It is most important to bear in mind that marked atrophy does not occur in hysteria. There is, however, in many cases of prolonged hysterical palsy, undoubted diminution in the size of the muscles, a wasting analogous to that which follows simple disuse. Hysterical paralysis is quite commonly associated with more or less sensory loss, the anesthesia being limited to the part paralyzed, and this is what we would expect when we remember the great rôle played by the mind in hysteria. Hysterical paralysis is a combined sensory-motor palsy; the limb is cut out of the psyche of the patient as a whole. Its cortical representation as a unit is destroyed, involving of necessity all of its attributes, both sensory and motor. Now and then in the paralyzed parts an edema, more or less localized, associated with a bluish or mottled discoloration of the skin, makes its appearance—*l'œdeme bleu*. The same phenomenon is occasionally noted in regions in which no paralysis exists.

In traumatic cases, *hysterical paralysis* begins as a slight weakness and is for a time progressive. No general rule as to the onset of the palsy can, however, be formulated, as at times it is quite rapid. In almost all of the cases of traumatic palsy which I have had the opportunity of studying the palsy has come on in the course of several hours and has gradually deepened, not reaching its full development often for days and weeks. In rare cases it may come on immediately. Sometimes it is exceedingly short in duration, but when once established in traumatic cases, is apt to persist for a long time; especially is this true in cases in which litigation is an element, for the mental attitude here is similar to that already described as being present in cases of traumatic neurasthenia with litigation. In other cases, again, the paralysis, having once disappeared and been recovered from, may recur after an interval has elapsed, especially if there be some disturbing emotional cause—excitement, effort, or sudden fatigue. When recovery ensues from hysterical palsy, this recovery may either be slow, progressive, or sudden.

Like the sensory disturbances, the *palsies of hysteria* always indicate the presence of a psychic element. Thus, a hemiplegia hysterical in origin differs distinctly from a hemiplegia that is organic. Flaccidity rather than spasticity exists, and the paralyzed leg is dragged along the ground while the arm does not assume the position of the secondary contracture seen in organic disease. If contracture be present, it is apt to be characterized by the bizarre positions of hysteria. The gait differs of course, radically from that seen in organic hemiplegia. Further, the muscles of the face are never involved in hysteria; unmistakable involvement should at once suggest true organic disease. This is also true of the tongue, but to a less extent. If the tongue be involved and deflection take place toward the sound or non-paralyzed side, hysteria is at once suggested, inasmuch as the reverse obtains in organic hemiplegia. Now and then, though rarely, paralysis of the jaw, the patient not being able to chew or close the mouth, is noted. Hysterical hemiplegia is quite frequently associated with hysterical hemianesthesia. This hemianesthesia, it should be remembered, differs radically from organic hemianesthesia. In the latter the sensory loss is most pronounced over the distal portions of the extremities, the hands and feet, and grows progressively less marked as the trunk is approached, and usually fades upon the trunk before the middle line is reached. In hysteria the anesthesia is equally intense over the limbs and trunk, and is usually very sharply defined by the middle line of the body; *i. e.*, in hysteria the sensations of the affected half of the body are cut off with knife-like precision. Very frequently, instead of an anesthesia, merely a hypesthesia is present; its character and significance are, of course, the same as those of full anesthesia. This is also true of hysterical hemiplegia; complete hemiplegia is an infrequent symptom of traumatic hysteria; a moderate degree of weakness, a moderate hemiparesis, is a much more frequent picture.

Paraplegia is not infrequently met with in traumatic hysteria. Occasionally it comes on in cases in which there has been a blow upon the back, though this etiology is by no means necessary. I have seen it also follow a fall upon the knees or buttock, and in its etiology strongly suggesting a true organic disturbance. It may also develop as an indirect consequence or accompaniment of a traumatic lumbago; the patient, feeling that motion aggravates the pain in the back, may sooner or later develop a more or less marked and sometimes complete immobility of the legs. Hysterical paraplegia is in these cases of very gradual development and is then apt to be very persistent. It is needless to add that there is here, as a rule, a more or less marked anesthesia, usually quite complete, of both legs, extending at times upon the trunk. Not infrequently in hysterical paraplegia the attitude and gait closely simulate those of double lateral sclerosis. The associated sensory phenomena, however, usually clear up the diagnosis.

Hysterical palsies of one limb are, as already stated, not infrequent in traumatic cases.

Instead of palsies, *contractures* are occasionally met with. These are, however, very rare in traumatic hysteria. Only rarely do they simulate the contractures due to organic disease. This is particularly true of the secondary contracture of hemiplegia. In hysterical paralysis of an arm the arm may also be contracted, and the position may be that of simple flexion or of some bizarre contortion. This may also be observed in the leg, though usually here the tendency is to rigidity with extension. Hysterical contractures of unusual muscles may also be noted; for instance, the muscles of the neck, and more rarely still the muscles of the face and tongue.

Occasionally tremor is observed in hysteria. The oscillations are to and fro, and, as a rule, relatively slow, varying from four to twelve in a second; most frequently from seven to nine. It is almost characteristic of hysterical tremor that the extent of the tremor increases during effort, especially if the patient be conscious of being under observation. As a rule, it is readily distinguished both from the fine tremor of paralysis agitans and the coarse movements of insular sclerosis. At times it simulates paralysis agitans, so as at first sight to suggest that affection—so much so that Oppenheim has made use of the expression "pseudo-paralysis agitans hysterica."

Now and then, instead of tremor or paralysis or contracture, hysteria may present the picture of an ataxia. Incoördination in these cases becomes evident only when the patients make the attempt to walk or at times to stand. As a rule, when the patient is lying down or sitting in a chair, there is power to move the legs normally in all directions. However, when the patient tries to get up, ataxia is at once manifested, and if he tries to walk, it usually becomes very pronounced. Hysterical ataxia, of course, differs in degree; but, as a rule, when present, it is quite marked. If the ability to walk be at all present, the gait in no way resembles that of locomotor ataxia. Great irregularity of gait, with, it may be, backward and forward or grossly bizarre movements of the trunk and arms, is the usual association of phenomena. The condition is technically termed *astasia-abasia*. Marked hysterical ataxia only infrequently results from trauma. In a large number of cases, however, a moderate degree of incoördination may be noted. This may be elicited by the test for station; or it may be revealed slightly in the gait. A certain degree of awkwardness is very frequently noted in the arms and hands, though decided incoördination is rare.

Convulsive seizures are very infrequent in traumatic hysteria. In rare cases, however, they do occur, and their recognition is important because in such cases a sharp differentiation from epilepsy due to trauma must be made. Hysterical attacks vary greatly in the symptoms which they present. They may be limited to comparatively slight emotional storms, attended by weeping and by laughter, or by transient alterations of speech and conduct in which emotional factors are so dominant that even the laity recognize the attacks as hysterical. Instead of being slight, the attack may be profound, and may then assume definite and fixed characters. The well-defined hysterical paroxysm is usually preceded by various emotional signs indicative of its approach. The patient, as a rule, becomes moody and depressed, avoids her family, keeps to herself, is irritable, presents lessened emotional inhibition, weeps upon slight provocation or laughs from equally insufficient cause. This period may last for a few hours or for several days. The sleep is often disturbed by dreams, and dream-like hallucinations with delusive ideas may persist in a variable degree during the waking hours. The patient also frequently reveals her disturbed mental state by abstraction, by indifference to dress and to proprieties. The appetite may be lessened or perverted. At times she is agitated and restless. If hysterical stigmata have already been observed in such a patient, they may now be more evident, or new ones may make their appearance. Sometimes a stigma, such as an inguinal pain, a clavus, or a globus acts as the starting-point for the motor disturbances. The onset of the convulsion is attended by tonic spasm, during which the patient may present rigidity of all the muscles of the limbs and trunk. In contrast with the epileptic seizures this phase of rigidity is, as a rule, quite prolonged. Sooner or later the tonic spasm is succeeded by clonic convulsions, and after a time these also subside and disappear. In contrast with the epileptic state, the patient is not unconscious, although, as a rule, she subsequently asserts that she has been so. Consciousness is at most somewhat perverted or but slightly submerged, so that not infrequently it is possible to rouse the patient and stimulate her to control her movements. Such a picture as that given may constitute the entire attack. In more pronounced cases, however, these symptoms are followed by a period during which the patient contorts the body into various bizarre positions and makes all sorts of gestures and extravagant movements; many of them suggest volition and purpose. Later on these violent and irregular motions give way to dramatic and passionate attitudes, accompanied or followed by noisy weeping, lamentation, and distress. By this time the patient seems fully cognizant of her surroundings, gradually becomes quiet, and the attack subsides; frequently she sleeps. Hysterical attacks are variously modified. Occasionally ecstasy is manifested during the paroxysm; at other times it simulates somnambulism. In still other cases, catalepsy, lethargy, or hysterical sleep may develop. Hysterical paroxysms, typical in character, as already stated, are for some reason rare in traumatic hysteria. Attacks relatively mild in degree are not uncommon. These are spoken of by the patient or the patient's friends as fainting spells, and have at times been mistaken for petit mal. Not infrequently such attacks interrupt the examination of the physician, and at times even the course of public trial.

The relation of trauma to the development of true epilepsy must, of course, in all cases be borne in mind, and a most careful study should be made in each case in order to determine the nature of the attacks. Especially is this the case when there has been direct trauma of the head. Here the possibilities of injury to the skull, to the dura, or to the cranial contents must be taken into account. We should remember that in epilepsy there are the total loss of consciousness during the attack, clonic convulsions, biting of the tongue, and relaxation of the sphincters. If a Jacksonian epilepsy be present, the convulsion is, of course, localized or focal. In such cases eye-ground changes should also be sought for. The absence of hysterical stigmata is also confirmatory of the existence of a pure epilepsy. The presence of the hysterical stigmata, on the other hand, argues strongly for a pure hysteria. While it is possible for a traumatic epilepsy and a traumatic hysteria to coexist, experience in a large number of cases convinces me that this must be an excessively rare occurrence.

Psychic Symptoms.—The symptoms of hysteria indicate, as already outlined, an alteration in the psychic state. When, therefore, we make a special study of the mental condition of the patient, special psychic symptoms become evident which are not only interesting, but important. There is—and this is true of almost all of the cases of traumatic hysteria —first an unusual emotional mobility, together with defective emotional inhibition. How readily such patients are upset by the physician's examination, and how "nervous" they become during what they describe usually as an ordeal, are so well known as hardly to merit comment. Weeping, exaggerated gestures, pseudo-fainting attacks, vehement protests and exaggerations, all of these are indicative of the mental state. In traumatic hysteria, as in traumatic neurasthenia, there is a marked tendency to depression; quite frequently the patient is tearful and despondent. On the other hand, there is in some cases a degree of cheerfulness which is out of all keeping with the presumably serious nature of the injury which they claim. Thus, I have known a man with a marked hysterical paraplegia to be relatively happy or at least manifest little worry or concern as to his condition.

The most important feature presented by the hysterical mind is its extreme impressionability. All cases of hysteria, and this is especially true of cases of traumatic hysteria, react abnormally to suggestions. That the events of the accident, as experienced by the patient, act powerfully in the way of suggestion, there can be no question. A slight trauma of the leg or of the arm may suggest a monoplegia of a limb. A blow upon the back may suggest a paraplegia of the legs. Indeed, the accident almost of necessity determines the special form in which hysteria presents itself. When we add to these facts the inadvertent and unintentional suggestions made in the repeated examinations of patients by physicians, and in the repeated rehearsal of the symptoms by patients, it cannot be wondered at that the symptoms become fixed and persistent, and also that new symptoms make their appearance. The mental attitude of hysteria is largely introspective, and it is easy of comprehension that the symptoms should present themselves in a greatly exaggerated and distorted form. Sometimes they believe that no one has ever been so hopelessly ill or in the same terrible way.

Visceral Symptoms.—Various visceral disturbances may occur, as is well known, in hysteria. Thus, there may be vomiting, rapid pulse, vasomotor phenomena, rapid breathing, coughing, yawning, retention of urine, anuria, phantom tumor, aphonia, and spurious aphasia or hysterical mutism.

Traumatic cases every now and then present the symptom of vomiting. This vomiting is quite frequently accompanied by a clean tongue and the absence of any definite signs pointing to indigestion. Usually the patient claims that she has absolutely no appetite, and a condition of true anorexia nervosa may be present, though this is rather rare in traumatic cases. Not infrequently the patient states that she vomits everything that she eats, that she retains nothing whatever, and yet in spite of these statements her general nutrition may be remarkably good. Indeed, she may present the general appearance of good physical health. At times also she states that she vomits blood or vomiting of blood is actually observed. In some cases of persistent vomiting the vomited matter is tinged with a small quantity of blood, a bleeding which probably does not come from the stomach. Vomiting of blood in quantity or of blood which has been subjected to the action of the gastric juice suggests, of course, a lesion of the mucous membrane of the stomach, and an endeavor should be made to determine the existence of ulcer. The well-known relations of ulcer to trauma of the stomach should be borne in mind, and yet we should ever be on our guard against the vagaries of hysteria. Blood from the nares may, of course, be swallowed and subsequently vomited—all in good faith by the hysterical patient.

Among other visceral symptoms may be noted increased frequency of the pulse; sometimes there is a more or less persistent tachycardia. At times also there are other disturbances, such as flushing, erythema, local edema, or so-called blue edema. In some patients there is present a marked pallor of the surface; especially is this true in paralyzed limbs; the latter frequently will not bleed to pin-prick. Quite frequently also we note *tache cérébrale*—dermographism; a stroke with the finger is followed by the appearance of a white streak, which soon becomes red and livid, and this discoloration may persist for some time. Hysterical rapid breathing is rather rare, and this is true of hysterical yawning and hysterical cough. Hysterical cough is every now and then accompanied by the expectoration of a small quantity of blood, a hemoptysis thus being simulated. The sputum is, as a rule, very small in amount and merely tinged with blood. Pus-corpuscles and tubercle bacilli are absent. Squamous epithelium and the not infrequent admixtures of particles of food show the source of the bleeding to be the mouth—usually the gums.

Rise of temperature is very rare in traumatic hysteria, as it is in hysteria of ordinary origin. A true hysterical rise, however, no doubt occurs in some cases, within a few hours or later, after an accident, and may persist for a day or two. At least a history of fever obtains in a small number of cases. The diagnosis of a purely nervous rise must be made by exclusion; its presence doubtless bears some relation to the degree of nervous shock sustained.

Disturbances of the sphincters do not occur in traumatic hysteria, though every now and then such disturbances are simulated, and are then apt to give rise to the diagnosis of true organic disease. When we recall the fact that a large number of traumatic cases present the symptom of increased frequency of micturition present during the day or night, or both, we can readily understand how the patient can mistake this for a defective control over the bladder. Especially is this true in women, in whom, as is well known, there is often present normally some feebleness of vesical control. Young girls and adult women not infrequently soil themselves in a fit of laughter or other emotional disturbances, and that this should occasionally occur in traumatic hysteria, in which the patients are emotionally greatly disturbed, is not surprising. It is exceedingly important, of course, to differentiate between this condition and that which is met with in true paralysis of the sphincter. Now and then hysterical retention of urine is present, so that it is necessary to empty the bladder with the catheter. This not infrequently happens when the hysteria is complicated by a traumatic lumbago, so that the act of micturition may be associated with increased pain in the back. The amount of urine, of course, may vary greatly. There may be an almost complete anuria, on the one hand, or pronounced polyuria, on the other. These symptoms do not differ from those met with in hysteria of ordinary origin.

TRAUMATIC HYSTERO-NEURASTHENIA.

(Traumatic Neurosis; Chronic Nervous Shock; Traumatic Lumbago.)

As already stated, a very large number—if, indeed, not the greater number—of the cases that exhibit nervous disturbances following trauma present the symptoms not of neurasthenia or hysteria alone, but of both affections more or less commingled. However, there are undoubtedly cases in which neurasthenia alone is present. The cases of pure traumatic neurasthenia and traumatic hysteria are readily differentiated by the respective symptomatology of these two affections. Further, the relative proportion of neurasthenic symptoms and hysterical symptoms in a given case can also be readily determined. As a rule, one or other of these groups of symptoms predominates. The case, other things equal, is grave in proportion to the prevalence and depth of the neurasthenic symptoms; hysteria of itself offering a rather more favorable outlook.

It is not at all an unusual experience, of course, to find associated with neurasthenia or hysteria actual physical injury. A not infrequent condition is that known as traumatic lumbago, a detailed description of which is not called for in the present article. However, a patient suffering from this complication presents pain upon flexion of the trunk forward, backward, or to either side, pain upon deep pressure over the muscles of the back, and pain upon jarring the trunk, such as is elicited by a fall upon the heels or sudden pressure downward upon the shoulders. Quite frequently, too, muscular spasm is elicited in the muscles of the back on attempted movement. The myotatic irritability of the muscles may also be greatly increased. The spasm is quite frequently elicited by slight tapping.

Just as there may be serious injuries to muscles, tendons, muscular insertions, ligaments, and bones, so there may be, of course, injuries of various viscera, and at times of the larger blood-vessels. Such was the case in a man aged forty-six who was struck at a railroad crossing, tossed many feet, and, in addition to severe bruises and contusions, subsequently developed a typical neurasthenic syndrome. He made little or no progress toward recovery, and finally, fifteen months after the accident, suddenly died. Autopsy revealed death to have been due to the rupture of a large fusiform aneurism of the thoracic aorta, the existence of which had been unsuspected during life. In view of the fact that previous to the accident the man had been in excellent health and had been free from alcoholism and syphilis, it is a legitimate inference that the aneurism, as much as the neurasthenia, was referable to the accident. Experiences such as these warn the examiner against the danger of overlooking organic injuries merely because of the presence of neurasthenia or hysteria. It cannot be too strongly insisted upon that the presence of functional nervous disturbances in no way negatives the existence of other affections, and these must be carefully eliminated.

Another instance of serious visceral injury was that of a woman, aged thirty-six, who received a severe blow upon the epigastrium in a collision and at once vomited blood. The vomiting recurred at intervals, was decided in amount, and the patient, when examined nine months after the accident, presented all of the clinical features of gastric ulcer. Stigmata of hysteria had also made their appearance, but the gastric ulcer and the attendant emaciation dominated the picture.

DIAGNOSIS OF NEURASTHENIA AND HYSTERIA.

In the diagnosis of neurasthenia or of hysteria the essential features of the symptomatology of these affections must be borne in mind. In neurasthenia there is, as has been pointed out, as the cardinal feature the extreme susceptibility to exhaustion, together with various pronounced fatigue sensations—tire, pains, and aches. Of necessity, these symptoms are almost altogether subjective, and many that are not subjective are from their very nature incapable of verification by the examiner. However, this does not by any means render the examiner helpless. We should remember that neurasthenia presents a definite natural history—that it is a clinical whole and not made up of disparate symptoms bearing no relation to each other. The patient will usually of his own accord tell of his weakened condition, how readily he becomes tired, will tell of his headache, backache, of the ringing in his ears, of his dizziness, of his broken sleep, and the host of other symptoms that go to make up the picture. In every statement we are confronted by the picture of ready exhaustion, of chronic fatigue, and, in so far as it is possible, the physical examination confirms the patient's statements. The dynamometer usually reveals a greatly diminished grip, an intention tremor—fine and obviously due to weakness—in the hands, a plus knee-jerk, lividity and coldness of the extremities, increased heart's action, and the like.

In the case of hysteria some of the stigmata of the affection, sensory, motor, psychic, or somatic, must be present, and as these are very definite in character, doubt is at once removed by their discovery. In the case of hystero-neurasthenia, the symptoms of both hysteria and neurasthenia must, of course, be present in varying degrees.

It is of utmost importance in every case to examine the patient for actual physical injury. It is, as a rule, not difficult to differentiate between organic lesions of the cord and hysteria or between a traumatic epilepsy and a mere hysterical attack.

As regards the painful points and areas so frequently noted in traumatic cases, it has sometimes been thought necessary by examiners to practise certain tests in order to determine the genuineness of the symptoms. Thus, it has been thought important to practise what is known as the "double touch": the operator, having determined the existence of a painful area, say over the back or spine, diverts the patient's attention to some other part of the body with his right hand, at the same time exercising pressure upon the supposedly painful spot with his left hand. The test is rarely necessary, especially if a typical nervous symptom-group is present. It would suggest itself, of course, in cases where malingering is suspected. It must be remembered, however, that in true hysteria, owing to the intrinsic psychic nature of the affection, the patient may not flinch under the double touch and yet the symptom be perfectly genuine.

Some years ago Mannkopf published a method of distinguishing between a localized pain that is genuine and one that is simulated. He stated that pressure upon a genuinely painful joint would cause a rise in the pulse-rate of upward of thirty beats, while in the case of a simulated pain, an increase is not noted. Later Rumpf maintained a similar position. Unfortunately, the symptom is very inconstant and therefore unreliable. In many patients with undoubted severe nerve or other pain it entirely fails. Of course, if in a doubtful case it is actually present and in a typical degree, it is of great value, and in such an instance simulation can be at once excluded. However, absence of the reaction means absolutely nothing.

Surgeons should be cautioned against too hastily deciding that a given patient is a malingerer. The time has long since passed when the reality or genuineness of the symptoms met with in the traumatic neurosis can be questioned. Every one knows that cases constantly occur independently of litigation. Some years ago Charles S. Potts placed upon record a series of cases drawn from ordinary hospital experience, and more recently Knotz has published a number occurring in one of the hospitals of Bosnia—Bosnia, be it remembered, having no law for recovery for personal injuries.

PROGNOSIS.

The question of prognosis embraces many difficulties. Not only have we to contend with the uncertainties attending the prognosis of ordinary neurasthenia and hysteria, but we have in many cases to estimate, in addition, the effect of the element of litigation. Each case must be judged by itself. General principles alone can be indicated here. We should first, if possible, determine whether in a given case neurasthenia exists alone; or in the case of hysteria, whether this affection alone is present. If both neurasthenia and hysteria are present, the relative proportion or degree in which these two affections enter into the symptom-compound should be estimated, and it is especially for this reason that a correct understanding of the symptomatology of these two affections is necessary.

Pure neurasthenia occurs in a relatively small number of cases; pure hysteria in a somewhat larger number; while both neurasthenia and hysteria are found in the great majority. In simple and uncomplicated neurasthenia the probability of recovery and the probable duration of the affection stand in direct relation to the gravity of the symptoms.

Neurasthenia is an affection which tends to recover, though usually only after a long course. Many patients recover in proportion as they comply with the laws of simple physiologic living, though such recovery is, as a rule, long deferred. If the neurasthenia be at all pronounced, the special measures implied by "rest treatment," partial or complete, alone are efficacious, and even here many months are required. Again, there are cases so profound that all measures fail or are only partially successful. In such cases a greater or less degree of permanence is established.

In estimating the prognosis of simple cases of traumatic neurasthenia, we must take into consideration not only the depth or intensity of the affection, but also the age of the patient. It is well known, for instance, that neurasthenia occurring in middle age or old age is far more persistent and difficult of treatment than neurasthenia in early life. Indeed, traumatic neurasthenia at such periods is often intractable.

Pure hysteria presents, as a rule, a very favorable outlook, as regards both the completeness of the recovery and the shorter duration of the symptoms. Here, again, the prognosis is influenced by the degree of the symptoms, and also by the time they have existed. Mild cases of hysteria recover, as a rule, very promptly and with little or no treatment; severe cases, on the other hand, may persist for years, and a few indeed become permanent. This last result may occur in traumatic cases in which litigation is absent. There is the well-known case of a soldier who developed, after a musket blow on the head, a hysterical spasm of the right arm—a spasm which resolved itself into a rhythmic movement and persisted up to the time of the man's death more than thirty years after. However, it cannot be too strongly insisted upon that hysteria of permanent character is very rare. The great majority of cases yield to simple methods of treatment—to the application of simple physiologic principles, such as rest, full feeding, massage, and especially suggestion. The removal of the element of litigation is a most important factor. The cessation of the anxieties and mental tension involved in the trial of a case, particularly if the outcome is favorable to the plaintiff, is often followed by a marked improvement of the symptoms. The patient's mind is no longer centered upon his condition; he is no longer the victim of auto-suggestion and of the unwitting though potent suggestions of counsel, physicians, nurses, or relatives. Gradually the various stigmata become submerged, they no longer rise into the field of consciousness, but disappear and are gradually forgotten. However, as I have already indicated, this is far from being an invariable rule; in patients in whom the symptoms have been pronounced and have endured for several years, persistence of the symptoms to a greater or less degree may be the result.

In cases of neurasthenia the elimination of the element of hysteria likewise exerts a favorable influence as to recovery, though this influence is less pronounced than in hysteria; and in cases of hystero-neurasthenia, it is the group of hysterical symptoms that are likely to disappear first—the undercurrent of neurasthenia persists much longer.

Delayed and prolonged litigation often exerts a very baneful influence upon the patient. The symptoms not only persist, but even seem to grow worse as time passes. This is true especially of cases of hysteria, in which it is not uncommon for the patient to claim at the second or third examinations that he is worse than at the first; and, indeed, all of the stigmata may be found to be much more pronounced. It is also noted in some hysterical patients, whose trial is long delayed, that there is an exacerbation of symptoms with every approach of a new term of court or a new date of trial. In the intervals the patient often presents signs of improvement, which give way to a full return of symptoms when the anxieties and tension of the trial recur.

There are cases, of course,—many of them,—that improve steadily, especially if under medical care, independently of the factor of litigation. This is especially true of neurasthenia and of cases in which neurasthenia predominates. On the other hand, there are unquestionably others who remain persistently the same or who steadily or periodically grow worse, as already stated. In some of these the symptoms are persistent, become profound, or are progressive for the same reason; and they would pursue such a course if no litigation were present. However, there are others, again, which impress the examiner—especially when repeated examinations are made—that they do not wish to get well, will not admit that they are getting well, and are determined not to get well until their cases are settled. How great a rôle the auto-suggestion of hysteria and unconscious or wilful exaggeration play here it is, of course, impossible always to say; each case must be judged by itself.

In cases that reach trial the examiner, acting as expert witness, is usually asked to describe first the injuries, secondly to give the diagnosis, thirdly to state whether or not the patient will recover, and lastly to state the probable duration of the symptoms. The last question is usually a very difficult one to answer. Approximate statements only can be made. In simple and uncomplicated neurasthenia a duration of a number of months can always be predicted. If the neurasthenia is grave, many months, and perhaps a year or two, may be required, and, indeed, as already stated, complete recovery may never ensue. One instance which may be given as an example was that of a farmer who was struck by a swinging timber in the small of the back and thrown to the ground from a considerable height. He fell upon his hands and knees, picked himself up, sat down upon a log, was exceedingly faint, and vomited, the vomited matter being streaked with blood. He consulted me several weeks afterward, when he presented all the typical symptoms of a traumatic neurasthenia, together with a typically painful back, a traumatic lumbago; there was also loss of weight. There were absent the apprehension and worry seen in litigation cases, but there was mental depression because the patient feared that he would no longer be able to support his family. He finally entered a hospital and was submitted to a radical course of rest treatment, which was persisted in for upward of four months. During all of this time full feeding, bathing, massage, and the other measures so well known as forming a part of this method of treatment were faithfully carried out. The result, however, was only partially successful. There was some increase in weight, some diminution of the nervous symptoms, and a decided improvement in the lumbago. However, he was not well, and, after leaving the hospital, continued to consult me at intervals for a series of years. He was never able entirely to resume his farm work, being obliged to limit himself to a mere superintendence, the care of poultry, etc. He had been permanently damaged.

In cases of hysteria and hystero-neurasthenia it is equally difficult to make a prognosis as to duration. It is safe, however, to assume in the majority of cases a number of months; in the more severe cases the tendency to persistence has already been pointed out. It is safe, also, other things being equal, to assume that cases are favorable in proportion as the symptoms of hysteria predominate.

TREATMENT.

The treatment of traumatic neurasthenia and traumatic hysteria does not demand in a surgical treatise detailed consideration. Suffice it to say that physiologic methods, rest, general hygienic living, good food, and in given instances a systematic and radical rest treatment, are the means employed. Such treatment should not, however, be unduly prolonged. Above all, is it of advantage—and this cannot be too strongly insisted upon—for the patient to return to his occupation. Work is one of the best physiologic stimulants, and there is nothing that will so promote a final restoration to health as occupation for both body and mind.

Strümpell has recently insisted that it is the duty of the physician who is first called to a case of accident to reassure the patient. There can be no doubt as to the wisdom of this procedure, and it is possible that in cases suffering from simple psychic shock or fright much might be accomplished in this way to prevent the subsequent development of hysteria. It is doubtful, however, whether in cases in which grave physical shock is present, or even profound emotional shock, simply reassuring the patient that he is not seriously injured will really prevent the subsequent development of nervous symptoms, as the symptoms, it should be remembered, are of rather gradual evolution and do not reach their maximum intensity for some time.

TRAUMATIC INSANITY.

Trauma such as produces traumatic neurasthenia or traumatic hysteria never leads to mental disease. It is perfectly true that persons suffering from traumatic neurasthenia frequently become depressed and introspective, and at times hypochondriacal and nosophobic. However, I have never observed a true psychosis develop in such cases. A history of trauma associated with the developmental period of a melancholia or a mania is excessively rare, and in no case in my knowledge has trauma borne an etiologic relation to the affections named. Not even can the value of an exciting cause be ascribed to trauma. Melancholia and mania (the manic-depressive group of modern writers) are affections dependent upon an essential neuropathy; they are nervous affections possessing an intrinsic pathology of their own, and bear no relation whatever to trauma. It is interesting to note that even when an individual the victim of the manic-depressive psychosis is subjected to traumatic nervous shock, it is not melancholia or mania that is produced, but ordinary traumatic hysteria, neurasthenia, or the more frequent compound hystero-neurasthenia.

Now and then, as the immediate result of the fright or shock of an accident, a patient will become for a time dazed, delirious, or confused. Such mental disturbances are usually of very short duration. Persistent delirium or confusion following fright is excessively rare.

Trauma of the head may give rise to contusions and lacerations of the scalp, to fracture of the cranium, to contusion or inflammation of the meninges, and to contusion, hemorrhages, or laceration of the brain substance. The variety of the lesions possible forbids of itself a general statement as to the psychic symptoms. It is a well-recognized fact, however, that no group of mental symptoms exists especially referable to trauma; that is, there is no syndrome which can be designated as the traumatic psychosis. The more we study the subject, the more evident does it become that trauma is of but small significance in the etiology of mental disease. Severe trauma of the head may, of course, be attended by concussion symptoms, and these may later be followed during convalescence by the signs of mental weakness, but even here it is rather the symptomatology of neurasthenia that is present than that of a dementia. Focal lesions may give rise to focal brain symptoms—*e. g.*, a Jacksonian epilepsy—rather than to mental symptoms, unless the lesion be diffuse. A traumatic meningitis may rarely be accompanied by a delirium, as in the case reported by Wagner (see Stolper); repeated blows on the head may have been followed by confusion, which may be very persistent, and by mental weakness, as in the case reported by Schüller. That more or less permanent impairment may follow severe brain injuries, such as gunshot wounds, fractures, loss of brain substance, goes without saying. Here focal symptoms, confusion, and more or less dementia constitute, as a rule, the symptom-group. Such cases may be properly spoken of as traumatic insanity—traumatic confusional insanity or traumatic dementia, as the case may be.

When mental symptoms follow slight traumata of the head, it is a justifiable inference that a hereditary or acquired predisposition to mental disease has existed; such cases are very rare. Illustrations are afforded by patients who become delirious or confused after slight blows, and by the rare cases of paresis in which trauma of the head seems to be an exciting cause.

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CHAPTER XXXIV.

SURGERY AMONG THE INSANE AND THE SURGERY OF INSANITY.

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Impairment, Diminution, and Exaltation of Sensibility in the Insane.—Insensibility to pain and to heat or cold is not at all uncommon in insane persons, and may be due to disturbance of the sensory nerves of the periphery or to the failure on the part of the consciousness to recognize sensations of pain. Impairment of the sensory nerves produces surface anesthesia. Surface anesthesia is not nearly so common as is a lack of the conscious appreciation of painful impressions; when it exists, it is localized, rather than diffused. When the impairment is due to the inability of the nervous centers to appreciate pain, the manifestation of the defect is, of course, general. The latter condition is always, and the former condition is often, associated with impairment of tactile sensibility.

On account of impaired sensibility, insane individuals may make no complaint of, and, in fact, may give no sign of, the existence of lesions and injuries that in the sane would be productive of grievous suffering. Insane persons may injure themselves intentionally or accidentally and give no evidence of pain. It is owing to a defect in the cutaneous sensibility that so many of the insane do not seem to suffer from cold or heat, even when improperly clad and greatly exposed. Impairment of cutaneous sensibility is frequently observed in paresis, melancholia, stupor, dementia, mania, toxic insanity, and paranoia. I have seen an insane woman laboring under a fracture of both bones of one forearm wave the extremity about as though it were sound. Harding[1] speaks of a lunatic who, after his intestine "had been ruptured by a kick from another patient," walked to the dining hall, took tea, returned to his ward, and went to bed, "not only without complaint, but without anything unusual in his appearance." Peterson[2] states that he has performed a post-mortem examination on a female acute maniac who had died suddenly. He found acute peritonitis from rupture of a duodenal ulcer. The peritonitis had existed for several days, but her turbulence had continued uninterruptedly to the last, and the condition had not been recognized during life. J. T. W. Rowe[3] refers to a patient who fell over a doormat and broke his femur. The bone protruded through the soft parts, but the patient attempted to walk and gave no heed to the injury. The same writer speaks of a paretic who fell down and fractured twenty-one ribs. This patient survived for a number of months and never complained of pain.

Hyperesthesia is much less common than is anesthesia, and is apt to be localized, rather than general. It may lead to complaints of curious sensations and of pain in regions that present no evidence of injury or disease; it is frequently the basis of hallucinations. It may be met with in mania, toxic insanity, and paranoia. Violent acute neuralgia occasionally occurs in mania and in epileptic insanity. In melancholia, precordial distress is common. It is thought to be a condition of bronchial spasm associated with cardiac uneasiness, induced by centric irritation of the pneumogastric nerve. Hyperesthesia of the mucous membrane of the esophagus is not at all uncommon, and may lead to spasmodic contraction of the muscular fiber, that is, to spasmodic stricture.

Anesthesia of the gastro-intestinal tract may be responsible for the failure of a surgeon to diagnosticate a lesion; for instance, cancer of the mouth, pharynx, esophagus, stomach, or rectum; ulcer of the stomach or rectum; ulcerated hemorrhoids; fissure of the rectum, etc. I have seen cases in which the esophagus was so insensitive that the stomach-tube could be passed without the slightest pain, spasm, or annoyance. Aberrations of organic sensibility are responsible for many visceral delusions; for instance, the idea that the stomach contains some foreign substance or is absent, that the intestines are blocked up or cut, that the liver has rotted away, that the heart has ceased to beat, etc.

A physician in a hospital for the insane should always be awake to the possibility of these alterations of sensibility. His patients should be carefully and regularly examined, search being made particularly for injuries and for various diseases. A ward nurse should report to the ward chief every fall, every fight, and every struggle between patients or between patients and attendants. On the reception of such a report the ward chief must immediately see the patient; examine him for wounds, bruises, etc.; and, if necessary, send for the physician at once. In every case a full report of the occurrence must be made out and handed to the physician.

The physician must not rest complacent in the conviction that because a patient makes no complaint, nothing is wrong with him; neither must he attach undue importance to allegations of supposed visceral disease or injury, but when a patient claims to suffer or to have been injured an investigation should be made in order to avoid the possibility of some disastrous error. A normal pulse, temperature, and respiration, with an unimpaired appetite, furnish strong presumptive evidence, although not absolute proof, that there has been no serious injury and that there is no grave disease.

Liability to Injury.—The insane are very liable to injury; and, as previously stated, owing to alterations in cutaneous sensibility, an injury in many of them does not cause pain. The injury may be purely accidental, as when the subject of epileptic fury, melancholic frenzy, or of maniacal furor collides with an obstruction, dashes his head through a pane of glass, or falls upon the floor or out of a window. A demented person may injure himself accidentally by walking off of a balcony or a landing; by stumbling against furniture; by cutting his lips and tongue while chewing glass or some other foreign body; or by creating a cutaneous ulcer, through repeated automatic rubbing, picking, or biting. The great majority of the injuries received by demented patients result either from pure accident or from motiveless and automatic acts. Paretics are particularly liable to injury. They are turbulent, excited, and destructive, and suffer from epileptiform seizures. They develop incoördination and are apt to stumble and fall. They fight with the patients and with attendants and make violent resistance to being cleaned or cared for. Bruises are developed from trivial force, pain is not appreciated because of blunted sensation, and the bones are brittle and break from the slightest force.

Injury may result from *self-mutilation*, which may be grave or trivial. Grave self-mutilation is uncommon, but occasionally occurs; and the patient may gouge out an eye, gnaw off a finger, tear out the testicles, cut off the generative organs, or inflict some other dreadful injury. I have known of two instances in which lunatics emasculated themselves because of delusions. Trivial or minor self-mutilation is very common. A patient exhibits the tendency to inflict minor self-mutilation when he strikes himself with his fist, bites his nails to the quick, bites and picks the skin, runs pins into himself, plucks out his hair, dashes against a wall, etc.

Self-mutilation may be due to the existence of delusions; for instance, the patient may injure himself as a punishment for some supposed sin to exhibit his unworthiness, to avoid venereal disease, or to obey the direct commands of hallucinatory voices. In delusional self-mutilation the patient usually seeks—and perhaps seeks a number of times—to mutilate a particular part by a particular method; and even when the opportunity for mutilating another part or for inflicting injury by another method is presented, he utterly disregards it, and seems to be dominated by some absolute necessity to accomplish it in a particular way upon the region to which his delusion points.

Self-mutilation may be purely automatic. We have mentioned some of the automatic acts of dements. They are due to restlessness and anesthesia. A demented individual may swallow nails, stones, glass, and many other foreign substances. He may pick a deep sore in some part of his body. He may rub an area until it is abraded; and continue to rub it, though it is raw and bleeding. It is perfectly useless to tell him that he must not do this thing. He either does not grasp what is said or he immediately forgets it; and he is entirely devoid of inhibitory power with which to effect restraint.

Some of the victims of melancholia make habitual movements like those of dements, and these movements finally become automatic. They are particularly apt to gnaw the fingers, bite the lips or the tongue, bite the nails to the quick, pull out hairs, or rub a cutaneous area raw. In some cases of melancholia it may be possible to cause the patient to abandon the habit by giving him repeated commands to that effect, and en-forcing the command each time it is given. If such patient and persistent efforts are kept up for a considerable length of time, they may prove efficient in melancholia; and the effort at effecting improvement will be greatly aided if the patient can be persuaded to do some work,—for instance, housework,—and if he can obtain a good deal of exercise in the open air.

Self-mutilation may result from attempted *suicide.* Acute maniacs may suffer injury or may actually kill themselves by accident, but they do not do so from deliberate design. In epileptic insanity suicidal impulses that are absolutely unconscious may arise. Most of the subjects of melancholia want to die, and many try to kill themselves. Women are more frequently suicidally disposed than are men; but when men are suicidal, they are more likely actually to try to commit suicide than are women.

When a melancholiac is bent upon suicide, he desires death ardently, but usually by one particular method; and he may pass other means by regardlessly, in the search for the especial mode that captivates him. One of my patients wished to kill herself by means of a saw. One day she got into the yard of the hospital and tried to reach the tool-house in search of this implement. In her peregrinations she passed half a dozen articles with which she could perhaps have killed herself, but she never touched one of them.

Many patients talk about suicide, but by no means all of these self-threateners really try to commit it when the chance occurs. On the other hand, some never speak of it at all; but they wait for a good opportunity, and seize it the moment it is presented. Sometimes a patient with a suicidal bent makes automatic movements of a suggestive nature; for instance, drawing a knife across the throat.

The refusal of food may mean that a person is suicidal, but many lunatics refuse food without suicidal intent. They may refuse to eat because they think the food contains poison, some noxious material, or an explosive substance; or because voices have forbidden them to eat.

The attempts at suicide made by melancholiacs often fail through lack of the power to adhere for any length of time to a fixed purpose.

The suicidal attempt may fail, and yet be carried far enough to injure the person slightly or severely. The attempt may be entirely fruitless or actually absurd, as when a person tries to hold his breath until he suffocates or tries to choke himself with his own hands.

Suicidal attempts may result from terror at fearful hallucinations; from delusions, especially delusions of persecution; from fear of dying or of losing money; from hallucinatory commands; from weariness of life; from an all-absorbing, never-waning passion to be dead; or from overwhelming sudden impulses.

The act of suicide may arise from suggestion, a sleeping impulse having been awakened into activity by observing the means of suicide readily accessible. This must not be allowed to happen. The windows must be fixed and screened; and ropes, knives, matches, etc., must not be displayed or left about. At bedtime the clothes of suicidal patients must be examined, to see that nothing is concealed that might be used for suicidal purposes; and the patient's armpits and perineum should also be examined, to discover any weapon that may be hidden there. A suicidal patient will perhaps try to pick up some object during the daytime, in order that he may carry it to the room and use it at night, when alone or unwatched; or, if watched, that he may use it when covered by the bedclothes. Strings, buckles, corset-steels, sharp bits of wood, etc., should be regarded as dangerous weapons. Some female patients attempt suicide by strangling themselves with their own hair. A method that is not particularly unusual is for a patient to endeavor to choke himself by jamming rags or portions of clothing or the bed-sheet down the throat.

Every patient suffering from a form of insanity in which suicide might occur must be carefully and persistently observed, in order that the first signs of such a tendency may be recognized. When it is believed that it exists, an attempt should be made to estimate the strength of the desire, in order that the real danger may be measured and that the necessary precautions may be taken to prevent the consummation of the intention. The suitable surgical instruments and materials should always be at hand and in proper condition in a hospital for the insane, in order that the surgeon, if necessary, may be able to institute immediate treatment for any injury, whether it be trivial or severe.

The Swallowing of Foreign Bodies.—Foreign bodies may be swallowed purely by accident, as a piece of bone in a spoonful of soup. To prevent such accidents, the food in an asylum kitchen should be carefully prepared, and the soup should be strained before being served. Solid food should be divided into very small pieces before being given to a patient who bolts his food, and fish-bones should be carefully removed. A bolting patient should not be allowed to have crusts. Many paralytics are greedy, bolt their food in masses, and will, if possible, steal pieces from the plates of their neighbors. Only soft food should be given some of these patients, and some must be fed with a spoon. If a patient is nearly or quite stuporous, liquids introduced into the mouth may be swallowed or may enter the windpipe. Such subjects should be fed by means of a tube.

Patients should be carefully watched while eating. Each one should have a regular place to sit in, this place being selected so that that particular patient may have suitable neighbors, and also that they may be carefully observed. If a patient always sits in his regular place at table, it is easier for the nurse to remember him and all his peculiarities and tendencies. A paralytic lunatic should never be allowed to eat alone.

It is a bad plan to permit the members of their families to bring food to the inmates of a hospital for the insane.

When a patient is admitted into an asylum, the physician should at once find out whether he wears false teeth. It is safe for some lunatics to wear them; it is not safe for others to do so. If a lunatic has false teeth, he may swallow them by accident or design.

Foreign bodies, such as bits of glass, nails, or pins, may be swallowed with suicidal intent. Such an attempt may succeed, but seldom does so. In some cases, although the intention is suicidal, the means employed are inadequate or utterly absurd. In one reported case an individual with suicidal tendencies swallowed a gold spoon; another swallowed seven pieces of wood, each piece being four inches and a half in length.[4]

An insane person, as the result of a delusion, may swallow some strange or disgusting substance, or may swallow a great number of diverse articles of small size. Dements, especially senile dements, often exhibit an instinct that is always present in infancy. This instinct leads them to put into the mouth all sorts of things, which they may, either by accident or by design, swallow.

The stomach of a lunatic may be remarkably tolerant to a retained foreign body; and probably many patients get foreign bodies in the stomach which remain there unsuspected during life. One of Foville's patients swallowed an entire set of dominoes. In one reported case 1841 objects were found in the stomach at necropsy; and among these objects were one thousand shoe-nails.[5] Foreign bodies in the gastro-intestinal tract may cause immediate symptoms, or may cause later symptoms due to their weight or shape; may produce inflammation, adhesions, or perforation; may occasion sensations that serve as a basis for insane illusions; or may lead to vague nutritive disturbances.

Lunatics may introduce foreign bodies into the urethra, rectum, or vagina; a woman in the Insane Department of the Philadelphia Hospital stuffed powdered glass into the vagina. She did this because of a delusion that she must make herself bleed.

The treatment for foreign bodies that have been swallowed, have entered the air-passages, or have been introduced into the urethra, rectum, or vagina is determined by the ordinary rules of surgery. In the insane woman who introduced broken glass into her vagina, the late Dr. Levis poured plaster-of-Paris into the canal, allowed this to harden and entangle the glass, and then removed the plaster-of-Paris with the glass embedded in it.

Hanging and Strangulation.—This is rather a favorite method of suicide among lunatics, provided they can obtain the means. A patient in a hospital for the insane can seldom find an opportunity to suspend himself by the neck; it is much easier for him to find an opportunity to strangle himself. He may attempt this by twisting some portion of clothing about his neck; or he may, if he can obtain it, employ a rope or a string for this purpose. Women sometimes attempt to do it by using their own hair, if this has been left long.

If an individual is found suspended by the neck, he must immediately be cut down; and if he is found lying with some constricting body about the neck, this must at once be cut away. The mouth should then be opened, and an inspection made to determine that there is no foreign body pushed back into the throat. If the patient is not respiring, artificial respiration must at once be made. Tracheotomy may be necessary. Every attendant in the wards of a hospital for the insane should understand how to make artificial respiration.

Contusions and Wounds.—In insane individuals a very trivial injury occasionally causes wide-spread *ecchymosis;* just as it may in tea inebriates, alcoholic drunkards, and opium habitues. This tendency is especially strong in paretics. It is important to bear in mind that an insane person may develop areas of bluish discoloration resembling bruises, when no evidence can be found that force has been applied. The elder Spitzka[6] says that such discolorations are never linear, as are those resulting from blows with a stick.

It has been maintained by some authors that very early in the development of certain forms of insanity, wounds and ulcers heal with unnatural rapidity, but I have never seen a case that would tend to confirm this idea. It is certain, however, that in many lunatics wounds heal without the slightest difficulty. In some patients healing is delayed; and in some, infection is particularly prone to occur. When infection does occur, there may be great destruction from sloughing. If the bodily condition of the wounded lunatic is seriously impaired,—and it usually is in acute insanity,—there must be a lack of vital resistance; and suppuration almost certainly follows the introduction of pyogenic bacteria. Paretics are especially liable to infection, because of the lessened vital resistance brought about by trophic disturbances.

In insanity, *trophic and vasomotor disturbances* are common, and a wound in an area of such disturbance is likely to be very slow in healing or to suppurate profusely. Vasomotor disturbances may be exhibited by cyanosis and edema of the limbs. This condition is seen in stupor, and may be noted in dementia, paresis, and cases of insanity associated with central organic disease.

The condition of cyanosis and edema is called *blue edema.* It may occur in the hands and forearms, but is far more common in the legs and feet. The parts are swollen, because of edema; and, hence, pit on pressure. The color is leaden or ghastly blue. When blue edema exists, the urine should be carefully and frequently examined. In many cases, although not in all, renal disease will be found to exist. Local asphyxia, resembling the condition met with in Raynaud's disease, is not uncommon in old dements. It is met with especially in the lower limbs, and may prove the precursor of gangrene. A wound in an area of blue edema is always slow in healing, and is very apt to suppurate, slough, and spread.

Trophic disturbances may be exhibited by pigmentation of the skin, bed-sores, osseous fragility, muscular atrophy, perforating ulcerations, or shedding of the nails. Such disturbances are particularly common in paresis, dementia, and melancholia. A wound in an area of trophic disturbance will, at best, heal very slowly; it will probably become infected, and will not unusually slough.

As a rule, when a sane individual is operated upon or is wounded, a distinct rise of temperature is noticed in a few hours. This is called by surgeons the *postoperative rise.* Such a rise may not be noted in a lunatic who has been operated upon or injured; and when it is not, it is probable that the temperature before injury was subnormal, and has simply become temporarily normal, as the result of aseptic fever.[7] We cannot know this fact, unless the temperature has been taken before the injury or operation. In some lunatics, even severe infection of a wound produces only a slight or actually trivial elevation of temperature.

Most lunatics are restless; and a wounded lunatic, by restlessness, is apt to disturb his dressings. Furthermore, he may deliberately remove the dressings, because of restlessness or irritation, or through the influence of a delusion; or he may pull his dressings off automatically and unconsciously. Many wounded lunatics can be dressed surgically just as we would dress a wounded sane person; but if we fear that the dressings will be disturbed, they should be held in place and the part be fixed by means of plaster-of-Paris or silicate of sodium. In some cases restraint will be absolutely necessary.

Hæmatoma Auris, or Othematoma (the Insane Ear; Bloody Tumor of the Ear).—By the term hæmatoma auris we mean an effusion of blood between the perichondrium and the cartilage of the ear. This condition is said to arise only on the concave surface of the pinna. I have seen in the sane victim of fracture of the cartilage effusion of blood on the side of the ear toward the head as well as in the concave surface. Hæmatoma auris is vastly more common in men than in women; and it is usually unilateral, but may be bilateral. The cause of this effusion has long been a matter of dispute. It is known to be especially common among lunatics of particular types. Those especially predisposed to hæmatoma auris are the victims of paretic dementia, of acute mania, of chronic mania, of terminal dementia, and of epileptic insanity; in other words, forms characterized by excitement. Many psychiatrists hold that traumatism has nothing to do with the production of hæmatoma auris, but that the condition results from vascular and degenerative changes in the auricular cartilage; and that its onset is often preceded, perhaps for days, by redness and swelling of one or both ears, by redness of the face, and by injection of the conjunctivæ. As a matter of fact we know that in paresis the cartilages may undergo definite changes. These changes are fibrous transformation and local softening, perhaps associated with arterial degeneration. When such changes exist, a slight injury may be responsible for the production of a hematoma; or perhaps

Fig. 552.—Hæmatoma Auris (case in Insane Department, Philadelphia Hospital).

it may occur without any injury at all, being expressive purely of vasomotor and trophic disturbance. When a paretic is predisposed, by vasomotor and trophic disorder, hæmatoma auris may occasionally be bilateral. It is my belief that hæmatoma auris, even among the insane, is due to traumatism, except in some few cases among paretics.

It is to be borne in mind that hæmatoma auris is not limited to the insane, but that it occurs sometimes in sane individuals; and in them, we know, it is always due to injury. In a sound, healthy person, a severe injury is necessary to produce it. I have seen it associated with fracture of a cartilage. Even in an acute maniac or an epileptic maniac it is usually violent force that induces it. In a paretic dement, however, as previously stated, it may arise after a very trivial injury, or perhaps without any injury at all. I am convinced that it occasionally results merely from the pressure of lying upon the pillow. Traumatism is most apt to produce this lesion when the vessels are dilated, as during mania or any other excitement. Among the sane, hæmatoma auris is seen in prize-fighters and football-players. Von Bergmann[8] points out that it may arise in a child if a schoolmaster or a rough companion rolls the ear with the fingers. Among superintendents of hospitals for the insane the view used to be very common that violence had nothing to do with the production of the lesion. It seems strange that this view could ever have been accepted in our day, for the Greeks and Romans knew better, and in statues of boxers represented the ear shriveled as the result of hematoma. It will be remembered that the Roman boxers (cestuarii) wore on their hands stout gauntlets or leather straps loaded with lead. Such a gauntlet was known as the cestus, and by means of it a very violent blow could be inflicted. At the present day it is the belief of the surgeons that hæmatoma auris, except possibly in some few of the cases that occur among paretics, is always due to traumatism.

Pathology.—The vessels of the perichondrium may or may not be diseased. In most cases the condition arises entirely without warning; for instance, a patient goes to bed at night without it, and gets up in the morning with it. In some few cases, for a number of days preceding the appearance of the hematoma there is dilatation of the perichondrial vessels. The effused blood comes from the small vessels of the perichondrium and passes between the perichondrium and the cartilage. I have previously stated my conviction that traumatism is the usual cause; the more distinct the perichondrial hyperemia, the less the amount of force necessary to cause the lesion. In some few cases of paresis, in which the vessels have degenerated and the cartilages have softened, the condition arises without obvious traumatism. Von Bergmann[9] disputes the view that the hemorrhage occurs only on the concave side of the ear. He says that it may occur on both sides, but that, because of the rich lymph-supply on the side of the ear toward the head, the blood disappears soonest from there. The hemorrhage on the outer side absorbs very slowly; and the cartilage undergoes chronic inflammation, which causes thickening and cicatricial contractions. The hemorrhage is certainly not due to any disease of the blood. If the hematoma is incised and the blood is obtained and examined, it seems entirely normal; and examinations made of the blood taken from a distant region show no significant change. The elder Spitzka[10] has found hæmatoma auris associated with blood-cysts of the arachnoid.

When blood has been effused and a hæmatoma auris has formed, what is known as a blood-cyst exists, the fluid elements of which are slowly absorbed, so that the contents of the cyst become thicker and thicker, from clotting and from the growth of fibroblasts into the clot. The fibrous tissue springs from the wall of the cyst, which is composed of perichondrium. The perichondrium becomes adherent to the skin; a certain amount of new cartilage is formed and scattered through the scar-tissue; and there may be actually, here and there, some ossification. The contraction of the mass of new fibrous tissue and of the recent adhesions produces great deformity, and portions of the ear become curiously bent, corrugated, and puckered. The deformity may be such that the entire external ear is a crumpled, shapeless mass. Usually there is a rolling in and turning down of the helix and retraction of the auditory canal.[11] The contraction takes place in scar-tissue. The greater the amount of scar-tissue, the greater is the contraction; and the more extensive the perichondritis, the greater is the amount of scar-tissue. Hence, severe perichondritis leads to great deformity; if there is slight perichondritis, there will be comparatively little deformity.

In spite of v. Bergmann's statement as to the appearance of the lesion on both the concave surface of the ear and upon the side toward the head, it is the experience of those who deal with the insane that the lesion is usually limited to the concave surface of the pinna. Peterson[12] is of the opinion that the limitation is due to the fact that the blood-vessels of this portion of the ear are terminal arteries; and that in such vessels the mechanical resistance to passive or active dilatation is much less than in other regions of the ear, so that a hemorrhagic effusion is more likely to occur there.

Signs and Diagnosis.—Even though the lesion is limited to the concave surface of the pinna, the cranial surface may become involved in the subsequent cicatricial contraction. Hæmatoma auris is confined to the cartilaginous portion of the auricle; the lobule is never involved. The helix is the portion most commonly attacked, and the effusion may remain limited to this region. The left ear is attacked far more often than is the right; and even when both ears suffer, the left is usually the first to exhibit the condition.

The occurrence of anticipatory local phenomena has been occasionally noted during several days before the onset of the hematoma. One or both ears may be swollen and reddened, the face may be flushed, and the conjunctivæ injected. In most cases, however, there are no premonitory constitutional symptoms. It is thus seen that hæmatoma auris is usually sudden in onset, and is most apt to arise during the night.

The pain is very trivial until the lesion reaches a considerable size, when there is usually a certain amount of pain, due to tension. The hematoma may attain full size in a few hours; but usually, after it is first observed, it enlarges gradually; and this gradual enlargement continues for two or even three days.

A recent hematoma is a perfectly smooth, irregularly oval swelling; tender to pressure; occasionally, but not always, exhibiting heat; feeling tense to the examining fingers, if they are applied lightly, but fluctuating when a careful search is made. The skin is thin, glistening, and either smooth or exhibiting trivial elevations where there were formerly definite ridges or shallow depressions, where the auricular fossæ were placed. In the beginning the color is dark red or purple and the size of the mass varies from that of a plum to that of a hen's egg. After a few days, or even sooner, the edge of the hematoma becomes hard; this indurated periphery broadens day by day. When the cyst is fully distended and tense, the skin may give way and bloody fluid ooze out. In such a case serous fluid may continue to ooze for a long time, or infection may occur, and the patient may suffer from a prolonged purulent discharge. In other cases, after rupture, the opening closes and the cyst fills up again. Most cases do not rupture.

After a hematoma has attained full size it remains from one week to three weeks without undergoing any notable change, except that the periphery becomes broader and harder and the central area of fluctuation is constricted or disappears. At this period contraction begins and induces deformity. The lump ceases to be tender and begins to shrink. The skin, which was formerly glistening and tense, becomes wrinkled, and pressure usually detects crepitation. As stated before, the larger the mass of fibrous tissue, the greater will be the contraction and the deformity; although under the best of conditions, the ear will never become entirely normal.

It is usually stated that the hematoma met with in the sane is more tender, does not possess the plum-colored discoloration, does not spontaneously rupture, and is more completely absorbed, so that there is little deformity; but I have never noticed any particular difference between the affection in the sane and in the insane.

Prognosis.—It is usual to attribute very serious prognostic importance to the occurrence of a hæmatoma auris. It used to be thought that this condition signifies an incurable case of insanity. As a matter of fact, the condition is most liable to occur in the victims of the insanities that are incurable, but it may also occur in an insanity that is entirely curable. All physicians of extensive experience among the insane have seen instances in which patients who have suffered from hæmatoma auris have recovered mentally. If we knew that a hematoma had certainly been produced by violent injury, we should draw no particular deductions of an unfavorable nature from its existence; if we knew that a hematoma had come without injury, or from a very slight injury, we should be led to the conclusion that the patient was suffering from some grave and probably incurable condition of mental and physical degeneration, even if our previous diagnosis had been different.

Treatment.—The method of treatment often adopted in institutions is to use cold during the first few hours after the appearance of the hematoma, and then to paint the auricle with contractile collodion, to make pressure. Hearder warmly advocates painting the surface with cantharidal collodion. The liquid contents are thus rapidly removed, the hematoma becomes quickly solid, and the amount of subsequent deformity is lessened. There is no question at all that if a hæmatoma auris becomes infected, it ought to be freely opened and drained; but non-infected cases do not seem to be greatly improved by this method of treatment. In a non-infected case it is advisable to aspirate the fluid contents, repeating the procedure more than once, if necessary; and after each aspiration to apply carefully adjusted compression, for which purpose there is nothing more useful than collodion. The ear should be covered with cotton and bandaged, in order to protect it from injury; because either additional injury or infection, by increasing the perichondritis, will increase the deformity.

Fractures.—Fractures occur with frequency among the insane. They may be in normal bones, as the result of violence, and such fractures are particularly common in the victims of acute insanity with muscular excitement and in epileptic lunatics. It was recognized by Davey, in 1842, that in certain forms of insanity the bones become brittle. This brittleness is particularly noticed in paralytic lunatics, insane patients with tabes, persons with paresis, and old dements. Fractures occur especially in the ribs and, in old patients, in the head of the femur; but in paretics all the bones seem to become brittle. In senile patients there is always great alteration in the vertebræ, and it is a common observation that these patients lose height as they grow older.

The bones most usually broken are unquestionably the ribs, and it is important to decide in every case whether the injury has resulted from the application of violent force to bones of ordinary strength or from trivial force to extremely fragile bones. The answer to this question sometimes determines the gentleness or brutality of attendants and the orderly or careless management of a ward. Very unjust charges are frequently made against attendants. The turbulent paretics are particularly liable to fractures. In restraining them from injuring themselves or others a fragile bone may be broken. Rowe[13] speaks of a patient whose ribs were broken while a clean sheet was being passed under him. The surgeon must always bear in mind, as has previously been stated, that an insane person with a fracture may make no complaint of pain. This is notably true in fractures of the ribs. I have seen four instances of fractured ribs in lunatics in which there was no complaint of pain. It was maintained by Meyer[14] that the normal breaking-strain of the ribs is from 62 to 65 pounds, that in paretics it is only 44 pounds, and that in female senile dements it may be as low as 11 or 12 pounds. It is not a very unusual thing to discover at autopsy fractured ribs in a patient in whom during life the injury was entirely unsuspected. Guddon found sixteen such instances in one hundred autopsies, most of the fractures being old fractures that had escaped recognition.

An examination of bones that are in a state of fragility shows the bone-cortex to be thin, as from a wasting disease or old age, and there may be osteoporosis. In paretics there is no absorption of lime, as in osteomalacia, but there is, rather, an increase of fat and a destruction of the bone-elements proper. In the fragile bones of senile dements, however, there may be a distinct deficiency of lime-salts. When the ribs are brittle, the sternum is sure to be brittle as well, and the rib-cartilages are also usually involved, these cartilages becoming gelatinous. When the bones are in this condition, very slight violence may break one or more ribs. Paretics are most particularly liable to these fractures, because their bones are usually in a fragile condition, and they are violent and excited and, hence, are apt to sustain injury.

Whenever a patient falls, fights, is hit, or has a struggle or a convulsion, the attendant should examine him at once for bruises, and then report the incident to the physician or send for the physician immediately. If the attendant knows that a fracture of an extremity has taken place, he must immobilize the part by some emergency means, in order that no additional injury may occur from bone-fragments pending the arrival of the physician.

It is always disturbing to have a patient suffer from a fracture, unless there is undisputed testimony as to how it has happened. Unquestionably, at times, fractures result from the carelessness or perhaps the brutality of attendants. As Maudsley[15] pointed out in speaking of fractures of the ribs, these injuries are uniform in character, and "must arise from a uniform cause." I believe, however, it is seldom that patients come to harm from carelessness or brutality on the part of attendants. I agree with Rowe[16] that, "as a matter of fact, hospital nurses are a hard-worked body of men, and compare in every way with men engaged in similar work of this nature." Attendants are not angels, fit for translation to a higher sphere; they are hard-working and often ignorant persons; the best class of people cannot be obtained for this work as a regular thing, unless the compensation for such services is made much higher, and now and then a cruel or an indifferent man may get an appointment, but such a man is soon found out and removed.

If a bone the seat of the change causing fragility shall happen to be broken, there is little tendency to repair, and the best we can usually do is to apply some support or put the patient in bed, the course selected depending on the bone fractured.

If a healthy bone is broken, we try to obtain repair. In some insane patients it is easy to treat a fracture; but in many of them it is extremely difficult. The paralytic lunatics and many of the paretics are feeble and violent, and this restlessness makes them extremely difficult to treat. It makes it necessary, usually, to put on irremovable dressings; and it may require the use of restraint, and perhaps the use of sedative drugs.

The fractures that are particularly liable to remain unrecognized are those of the ribs and of the lower end of the radius. It is well to take especial precautions to prevent the occurrence of fractures in a feeble and violent patient, who is apt to fall from the bed or against its sides, by making them sleep on a mattress upon the floor or in a crib.

Dislocations.—Dislocation of the wasted head of the femur may occur in a lunatic suffering with locomotor ataxia. Dislocations are not very uncommon in epileptic lunatics, and I have seen dislocation of the jaw occur in such a patient. The humerus is most commonly the bone dislocated. Trophic arthropathies are not unusually met with in certain forms of insanity, and the chondrosternal articulation may be the seat of such a change. Lloyd, Brissaud, and Joffroy have reported cases of trophic arthropathy in paresis associated with tabetic symptoms. Etienne and Perrin[17] state that there may be tabetic arthropathy in paresis without any of the symptoms of tabes, and that in such a case a joint may become swollen and subluxated, exactly as can a Charcot's joint.

There is nothing peculiar in the treatment of dislocations among the insane.

Suppuration.—We have already stated that many of the insane, owing to lessened vital resistance, vasomotor disturbance, or trophic disorder, are particularly prone to suffer from infection. The patient may get a boil, several boils, or many boils, and may suffer with carbuncles, acute abscess, cellulitis, or sloughing. It was long taught that the onset of an acute suppurative process might prove of benefit to an insane patient, acting, it was said, as a derivative, and heralding a crisis in the condition; hence the idea that in mental disease boils are of critical significance. I have never seen an outbreak of suppuration that I felt to be of benefit to any one, and I entirely doubt the favorable prognostic import of suppurating foci in insanity; although I believe that it is a fact that when an epileptic lunatic suffers from a suppurating focus, and that suppurating focus induces fever, the fits are likely to be absent while the fever exists. I have previously referred to the interesting fact that the temperature of an insane man suffering from suppuration may be normal, or but slightly above that point, when one would infer from the degree or gravity of the process that the temperature should be greatly raised. The explanation of such a phenomenon, when it occurs, is that the temperature had previously been subnormal, and was pushed up to normal or slightly beyond by the suppuration.

Suppuration is most common in the subcutaneous tissues, and is produced by bacteria entering abrasions or being rubbed into the skin with dirt. It is most common in those who are dirty in their habits, but is not unusual even in those who are cleanly, are bathed often, and wear clean linen. Paretic dements are particularly liable to develop pustules on various parts of the body, especially on the back and buttocks. The suppuration in such a pustule may remain limited or it may spread widely. In some cases gangrenous cellulitis occurs. It is in this way, usually, that *bed-sores* begin in a paretic, and such a bed-sore may form in a few hours. It may undergo sloughing, may produce death, or may perhaps heal. Suppuration of the glands of the neck is rather common in insane patients, and results, I believe, from foulness of the mouth and the formation of ulcerations in that cavity. I have seen several instances of swelling of the parotid gland that could be attributed to the same cause. Abscess of the liver also occurs in the insane, but I doubt whether it does so more frequently than among the sane. The same may be said of abscess of the brain. Ulcers may occur in insane patients, as they do in sane patients. What is known as the perforating ulcer occurs particularly in patients suffering with locomotor ataxia and in those who have developed peripheral neuritis.

Erysipelas.—Erysipelas may occur in the insane as among the sane; and in the broken-down and debilitated subjects in an asylum it may prove a very fatal condition. Insane patients, when the subjects of erysipelas, are apt to become extremely delirious. It has been maintained by some alienists that erysipelas occurring in the sane may induce an actual acute mania, or during the convalescence from an erysipelas melancholic depression may arise. Some observers have maintained that erysipelas has a favorable critical significance in acute cases of insanity.

Gall-stones.—The incidence of gall-stone disease among the sane varies with age, sex, race, climate, occupation, and habits. The disease is more common in cold and damp, than in warm and dry, countries. It is more common among Caucasians than among negroes. It is very rare before the age of thirty-five years, and is seldom met with before the age of forty, but increases in frequency with every year after forty and is most common between fifty and sixty. It is more frequent in women than in men, the proportion being about five to three. Among the insane there seems to be the same predispositions of age, sex, race, etc.

In England and America gall-stones are found in about 7 per cent. of the necropsies made upon the sane. It has long been believed that the condition is much more common among the insane. We know that biliary calculi are very common in women laboring under chronic insanity. Male chronic lunatics probably suffer from the condition somewhat more commonly than do sane persons, but not nearly so commonly as do insane women.

Often—in fact, usually—no symptoms are noted during life, and it becomes known only at the post-mortem table that gall-stones have been present. On several occasions I have seen numbers of calculi removed post-mortem from persons who, during life, had not presented a single symptom to indicate the presence of the stones. In fact, the diagnosis is made during life in less than one-fifth of the cases.

It thus becomes obvious that opinions as to the incidence of gall-stones among the insane are entirely fallacious, unless they are founded upon consecutive necropsies, and a careful study of such reports seems to make it evident that cholelithiasis is more common among the insane than among the sane. Why it should be more common is not entirely clear. It is not the insanity which causes the gall-stones, but the cholelithiasis develops because of associated conditions or accidental circumstances. We know that fright can cause jaundice, and it is believed by some authors that mental depression increases the amount and alters the composition of the bile. From these statements we might be led to infer that patients laboring under melancholic depression would be most particularly liable to develop cholelithiasis, but statistics do not indicate that this is so. It is true that it may occur in melancholia or in hypochondriacal melancholia, but it seems almost equally common in other chronic insanities; and it is decidedly more common in elderly chronic dements, particularly female dements, and those who are becoming fat. It is more common in those suffering with heart disease than in those free from cardiac trouble. Its victims are most often those who bolt their food, are constipated, take an insufficient amount of outdoor exercise, and drink too little water.

The statistics of the frequency of gall-stones among the insane vary greatly. I sent a circular letter to many chief physicians of hospitals for the insane, and a number of them were kind enough to make answer to my questions. The answers exhibit great diversity of opinion. Some think the condition extremely common. For instance, Quimby, of Worcester, Mass., believes that it is present in 35 per cent. of females at necropsy. Many believe that there is no particular liability among the insane; and among those holding this opinion are Chapin, of the Pennsylvania Hospital for the Insane, and Chase, of the Frankford Asylum, Philadelphia. Tomlinson, of the State Hospital at St. Peters, Minn., thinks that 2 per cent. of the patients admitted suffer with cholelithiasis, and that gall-stones are found in 5 per cent. of necropsies. Many chief physicians responded by saying: "Not peculiar, or uncommon, or frequent, or unusual." Some of the reports would indicate that the condition is less frequent than among the sane, and some would suggest that it is extremely rare. For instance, Urquhart, of James Murray's Royal Asylum, Perth, Scotland, has met with only 4 cases in 101 necropsies.

The only answers that can really be utilized in endeavoring to reach a conclusion are autopsy reports in which the number of autopsies, as well as the number of cases of gall-stones found, is given. Unfortunately, in these reports the sex is not often stated. Heard, of the Buffalo State Hospital, reports 40 cases in 331 autopsies; King, of the State Hospital, Talmage, Cal., reports 5 cases in 146 autopsies; Lamb, of the State Hospital, Fishkill-on-Hudson, N. Y., reports 17 cases in 146 autopsies; Noble, of the Hospital for the Insane, Middletown, Conn., reports 18 cases in 50 autopsies; Chase, of the Friends' Asylum, Frankford, Philadelphia, reports 2 cases in 14 autopsies; Urquhart, of Perth, Scotland, reports 4 cases in 101 autopsies; Spence, of the Brentwood Asylum, Litchfield, Eng., reports 19 cases in 400 autopsies; and Tuttle, of the McLean Hospital, Waverly, Mass., reports 3 cases in 91 autopsies. The totals make 108 cases in 1279 autopsies—over 8 per cent. of the entire number.

In the treatise on "Gall-stones" by Brockbank we find a table setting forth the findings in 2412 post-mortem examinations upon the insane. This table was founded on the reports of Beadles, Snell, Warnock, and Goodall. Goodall estimates that at 20 per cent. of necropsies gall-stones will be found. Beadles says they are found in 36 per cent. of the females, and Snell states that they are discovered in 9.2 per cent. of the males and in 19.4 per cent. of the females. Warnock's belief is that they exist in 11 per cent. of males and 50 per cent. of females. Our conclusions are that gall-stones are more common among lunatics than among the sane, and are considerably more common among the female insane, and among chronic lunatics than among acute lunatics, and that in the majority of cases there are no symptoms during life.

Cholelithiasis is due to many conditions: to insufficient open-air exercise; to constipation; and, most of all, probably, to attacks of catarrh of the duodenum, with secondary catarrh of the bile-ducts and the gall-bladder. The existence of chronic dyspepsia, manifestations of pain in the right hypochondriac or epigastric region, or an attack of jaundice, would lead a surgeon to suspect the presence of gall-stones, and to endeavor to determine whether they are present.

W. H. Hassell, late of the Norristown Hospital for the Insane, has furnished me with the records of 354 post-mortems, 139 of these being upon men and 215 upon women. Of these, 18 men and 51 women were found to have gall-stones, that is, about 13 per cent. of the men and nearly 24 per cent. of the women. The average age of the men with gall-stones was fifty-three years; the average age of the women, fifty-seven. The oldest man was eighty-three; the youngest, twenty-four; and 4 of these 18 persons were under forty years of age. The oldest woman was eighty-eight; the youngest, twenty-one; and 7 of the 51 persons were under forty.

These figures indicate that gall-stones among the insane occur about three times as frequently in women as in men, and a rather unusual number of both women and men as compared with the sane are under the age of forty years.

There were 21 post-mortems made upon male chronic maniacs, without one instance of cholelithiasis; but among 40 female chronic maniacs there were 6 with gall-stones. In 6 male acute maniacs there were none with gall-stones; in 10 female acute maniacs there were 3 with gall-stones. There were 16 women with epileptic insanity, either mania or dementia; and 5 of these had gall-stones; but in 6 men of the same type there was not an instance of gall-stones. Fifty-six male dements (organic, senile, terminal, and chronic) were subjected to necropsy, and in 9 of them gall-stones were found; 79 female dements came to autopsy, and in 27 of them gall-stones were found. In 16 males with chronic melancholia there were 3 with gall-stones; and in 23 females with chronic melancholia there were 7 with gall-stones.

These figures show, in the various forms of insanity, the greater frequency of cholelithiasis among women. They also show that the condition is rather more common in chronic melancholia than in some other forms of insanity, but that it is particularly common in dementia.

Appendicitis.—Appendicitis is not more common among the insane than among the sane. In fact, I am inclined to believe that it is less common. The answers received to my circular letter indicate that this is the general opinion, although Tomlinson, of the State Hospital, St. Peters, Minn., thinks that 1 per cent. of the cases admitted present evidences of some appendical trouble; Chapin, of the Pennsylvania

Hospital for the Insane, is convinced that the disease does not occur with any marked frequency; Heard, of the State Hospital, Buffalo, N. Y., has not seen a case for many years. King, of the State Hospital, Talmage, Cal., an institution containing 670 patients, has not seen a case since 1893. Noble, of the State Hospital, Middletown, Conn., an institution containing over 2400 patients, has seen 13 cases in two years. Foster, of the State Hospital, Williamsburg, Va., an institution containing 600 patients, has seen 1 case in seven years. Sanborn, of the State Hospital of Augusta, Me. (700 beds), has seen but 3 cases in five years. Spence, of the Brentwood Asylum, Litchfield, Eng., found no appendical disease in 200 male necropsies, and only one instance of it in 200 female necropsies. Drew, of Bridgewater, Mass., is inclined to believe that appendicitis is rather frequent among the insane. Tuttle, of the McLean Hospital, Waverly, Mass., has found no instance of appendicitis in 91 necropsies.

My own observations would lead me to agree with Christian, of the State Asylum, Pontiac, Mich.; that is, that in an institution for the insane, appendicitis is more frequent among the attendants than among the patients. We must bear in mind, however, that appendicitis, in some cases of insanity, may exist without any complaint of pain and without any abdominal rigidity; and it may be very easy to overlook the existence of the condition, or to fail to even suspect it. On the other hand, in certain conditions appendicitis may be simulated, and the gastric crises that occur in some cases of paresis may be mistaken for it.

Malignant Disease.—I do not believe that there is any particular difference between the incidence of malignant disease among the insane and among the sane of the same age. This is the conclusion of Blackburn, of the Government Hospital, Washington, D. C. Chapin, of the Pennsylvania Hospital for the Insane, says that the average is 6 cases in 265 female patients, and 4 cases in 181 male patients. Christian, of the State Hospital, Pontiac, Mich., finds 3 deaths in 184 due to malignant disease. Many of the answers to the circular letter would indicate that malignant disease is frequent among the insane. In the State Hospital, Buffalo, N. Y., of 645 deaths, 35 were due to cancer.

There are no especial rules to be followed as to diagnosis or treatment. The question has been discussed whether or not it is worth while to operate for malignant disease on a lunatic. Beyond any question, it is worth while if he has a curable form of insanity. It is also, in my opinion, worth while, even if he is suffering with an incurable form of insanity; for an insane person is as much entitled to be relieved of discomfort and distress as is a sane person. I have operated several times for cancer of the breast in female lunatics, and for cancer of the lip in male lunatics. I do not believe that the operative results are in any way directly influenced by the insanity.

Ulcers.—Various kinds of ulceration may occur in the insane. Some ulcers result from simple suppuration. The chronic ulcers of the leg, due to varicosity of the veins and associated with eczema, are often met with, particularly among pauper lunatics. Trophic ulcers are prone to occur in certain degenerative states, and ulcers are especially common in association with Bright's disease and diabetes. Tuberculous ulcers about the lips, the anus, or the rectum are sometimes met with; and syphilitic ulcers are, of course, now and then encountered. Perforating ulcers are occasionally met with in the victims of diabetes and in those suffering from locomotor ataxia or peripheral neuritis.

Gangrene.—Gangrenous *bed-sores* are liable to arise in delirious mania, in paresis, in paralytic dementia, in terminal dementia, and in advanced cases of senile dementia. Usually, when a bed-sore forms in a paretic individual, there are localized inflammation, suppuration, sloughing, and ulcer-formation; but in some of the cases an acute bed-sore forms by a gangrenous process. It enlarges rapidly, and is surrounded by suppurating foci and tracking sinuses. This type of bed-sore, the rapidly spreading, gangrenous condition, is the one often met with in acute delirious mania and in melancholic frenzy, and is an extremely dangerous condition, which may be directly responsible for the death of the patient. The treatment of bed-sores in the insane differs in no way from the treatment of the same condition in the sane.

Senile gangrene is not any more common among the inhabitants of asylums than it is among the sane. We would suppose that old dements, who are prone to suffer from local asphyxia and blue edema of the limbs, would be particularly apt to develop it; but such does not appear to be the case. John B. Chapin, of the Pennsylvania Hospital for the Insane, an institution containing, on an average, 440 patients, has seen but one case of it in twenty-six years. Nevertheless, some chief physicians have reached a different conclusion. For instance, Sanborn, of the State Hospital, Augusta, Me., says that he treats several cases of it each year, and he regards it as rather frequent. Wilson, of the Athens State Hospital, Athens, Ohio, which has a capacity of 1200 patients, has seen but four cases in seven years. *Diabetic gangrene* does not appear to be any more common among the insane than among the sane.

Hernia.—Hernia is very common among the insane. A number of years ago, when I was Chief Assistant Physician in the Insane Department of the Philadelphia Hospital, I estimated that one male patient out of every twenty suffered with hernia. The patients should be examined for this condition on admission, and they should subsequently be watched every time they are bathed, to see whether it has developed. Hernia is a dangerous condition in the insane. It is very liable to become strangulated, and the strangulation may escape recognition. Hernia is particularly common in elderly men suffering with dementia; and when strangulation occurs, vomiting may be practically the only symptom. An attack of vomiting in an insane person should excite suspicion of the existence of a hernia, and a careful examination should be made to detect the protrusion.

When an individual has a hernia, he should either wear a well-fitting truss or be subjected to an operation for radical cure. In acute excited conditions the patient will not retain a truss, and it is practically useless in them to undertake a radical operation. They cannot be kept quiet and the wound will be apt to be torn open and to suppurate. They must be watched with the utmost care, and the application of a truss should be undertaken the moment they will tolerate it.

In old patients—that is, patients beyond the age of fifty-five—there is but a poor prospect of success from a radical-cure operation; and if one is attempted, there is considerable likelihood of suppuration in the wound. In all patients under the age of fifty, if not laboring under an acute insanity and not presenting any visceral contraindication, it is advisable to perform a radical cure. I have operated on several such patients with perfectly satisfactory results. In each case I obtained primary union, and in each I applied a plaster-of-Paris bandage until the dressings were removed.

Knapp[18] warmly advocates operation in these cases. He has many times performed successfully the operation of radical cure. He calls attention to a fact I have previously mentioned in this chapter, that is, that an insane patient frequently has a subnormal temperature, so that a postoperative rise may only reach normal; and that even when pus is present, the elevation may be but trivial. He lays down the rule that if the temperature reaches 100° F. after operation, the dressing should be removed and the wound inspected; and, if necessary, drained. I believe this advice to be entirely sound.

Cystitis.—The urine in insane persons may be altered in quantity and changed in quality. In paralytic dements and in maniacs the phosphates, chlorids, and urea are frequently in excess, and in melancholia and some cases of dementia they are lessened in amount. Johnson Smyth[19] points out that in general paralysis and epilepsy there is an excessive quantity of urine secreted; whereas in melancholia and secondary dementia, the excretion is diminished. He asserts that the amount of solids excreted is notably increased in general paralysis, and that in the psychoses, with the exception of dementia, there is a slight excess of urea. In general paralysis, epilepsy, and dementia, he believes that uric acid is above the ordinary physiologic level, and that in epilepsy there is some excess of phosphoric acid. Albumin or albumin and casts are frequently found in the urine of the insane, especially in paretic dementia and other degenerative states. In some cases, acetone is found, and this is asserted to be particularly liable to be present in individuals who have been wildly delirious.

Retention of urine, incontinence of urine, and difficult and painful micturition are found among the insane, as among the sane, and from exactly the same causes. Inflammation of the bladder and stone in the bladder are most common in elderly persons with enlargement of the prostate gland. In paresis vesical crises may occur, and they are very deceptive. It used to be maintained by some authors that oxaluria is especially common among the insane, some going so far as to attribute to it a causal influence. I believe that it is more common in patients who are mentally depressed, particularly if they are dyspeptic and irritable. It may occur in any patients in an institution, if they obtain insufficient fresh air and exercise.

Tuttle, of the McLean Hospital, at Waverly, Mass., has made consecutive urinary examinations in 135 individuals, in 27 of whom he found calcium oxalate; but there was no cystitis of any consequence in any case. Spence, of the Brentwood Asylum, Litchfield, Eng., says that in males on admission cystitis with oxaluria is fairly common, clearing up with improvement in the patient's general condition; but in females, it is unusual. Blackburn, of the Government Hospital, Washington, D. C., finds that cystitis is very frequent among asylum inmates and is usually secondary to enlargement of the prostate. Christian, of the State Hospital, Pontiac, Mich., finds cystitis with oxaluria very common. Sanborn, of the State Hospital, Augusta, Me., finds it frequent in males, but rare in females. May, of the State Hospital, King's Park, N. Y., finds cystitis to be particularly common among terminal cases of paresis. Hattie, of the Nova Scotia Hospital, Halifax, N. S., finds that oxaluria is common, but that cystitis is rare. J. L. Green, of the State Hospital, Asylum, Neb., finds oxaluria present in 25 per cent. of the cases on admission.

THE SURGICAL TREATMENT OF IDIOCY AND INSANITY.[20]

Operations for Microcephalic Idiocy.—In 1890 Fuller, of Montreal, trephined an idiot in the hope of effecting an improvement in the mental condition. A little later than this Lannelongue, of Paris, devised an operation for the treatment of microcephalic idiocy. He called this operation linear craniotomy. He believed that in microcephalic idiocy the fontanels close prematurely, and that there is too early an ossification of the cranial sutures; consequently, that the brain is cramped and pressed upon by the rigid, non-distensible bony case. This operation was, for a time, performed frequently and by many surgeons; but, of late years, it has been practically abandoned.

The operation, if applicable at all, is to be recommended only for microcephalic idiocy; and this is a very unusual form, including, probably, not over 1 per cent. of idiots. My own opinion is that the operation is not justifiable, even in microcephalic idiocy. It is certainly true that in some microcephalic idiots the fontanels are found closed at birth, and in some of them the sutures do ossify prematurely. Further, as Jacobi has shown, there is, in certain unusual cases, premature ossification of the bones of the face and an unusually early eruption of the teeth. If microcephalic idiocy were caused by the above-mentioned conditions, there would be a reasonable foundation for the performance of Lannelongue's operation. The evidence, however, that microcephalic idiocy does not result from these conditions seems to be positive. The size of the head is not a measure of the intelligence of an idiot, and premature ossification of sutures is the rare exception, and not the rule. Bourneville has shown us that it is just as common in these cases to find the sutures closed less tightly than they should be as to find them prematurely ossified. Again, it has been shown by Gratiolet and Ireland that even when the sutures of the vault are ossified too early, those at the base lag behind in proper development. Further, we should remember the rule that soft parts dominate hard parts; therefore, an expanding brain would be more likely to expand the skull and thin its bones than a firm skull would be to limit brain-growth. Furthermore, the brains of microcephalic idiots exhibit no signs of pressure. As Sir George Humphrey has pointed out, the convolutions are definite and the sulci are distinct. In many cases of microcephalus, the spinal cord, as well as the brain, is small, and this condition could not have been produced by ossification of the vertebræ. The heart is frequently very small, but this could not have been produced by ossification of the ribs. Microcephalus probably begins before the fifth month of gestation, and at birth certain brain areas that ought to be present do not exist. In other words, the skull is molded to a small brain, an ill-developed brain, a brain that is insufficiently formed and is probably deformed, which may lack certain convolutions, and which does lack an abundance of nerve-cells that the normal brain contains. In idiocy there is a general maldevelopment. Many of these patients have rickets; some of them are blind; some of them are deaf; certain bodily structures may be absent; deformities are very common; and the skin is both relaxed and inelastic. I do not believe that the skull limits the growth of the brain, but think with Ireland that the brain and the skull grow together harmoniously.

As I do not believe that premature ossification is responsible for microcephalic idiocy, I never perform Lannelongue's operation. As I have stated on another occasion, the surgeon who removes a strip of the skull in order to cause the brain to develop acts as wisely as would a man in removing a section from the dome of a cathedral in order to increase the stature of the archbishop. Many reports have been made that apparently exhibit favorable results from the performance of this operation, and after its performance there is often some evidence of improvement for a brief time. The reason for the frequent temporary improvement is perfectly clear; the idiot, perhaps for the first time in its life, has been placed under orderly, positive, and scientific control. It is among new people and in strange surroundings. It hears unfamiliar voices and feels the effect of these various alterations from the normal. An anesthetic is given it, and it suffers from the shock of the operation. A powerful temporary effect may therefore follow. Further, idiots are liable to attacks of maniacal excitement; and the parents may not have thought of having an operation done until the attack of excitement occurs. The attack may subside after the operation, and the child return to its old level of reasonably quiet idiocy; but the family, and perhaps the doctor, look upon this return to the previous standard as a remarkable improvement.

The only treatment for idiocy is education, discipline, and hygienic care. Of course, in cases of idiocy certain complications may arise to justify operation, the operation being done for the complication, and not with any idea of curing the idiocy. Among those complications which may justify an operation are certain forms of epileptic attacks, muscular spasm, muscular rigidity, or paralysis. An operation done for any of these conditions may improve the patient's comfort, although it will not improve the idiocy. A cranial operation may be justifiable in traumatic idiocy or in idiocy in which there are positive pressure-symptoms.

Operations for Hydrocephalic Idiocy and Imbecility.—Hydrocephalus is a very fatal disease; most of those who suffer from it die within one or two years, many become idiots, and only a very few recover. In most cases of hydrocephalus mental weakness exists, and very often there is complete idiocy. A child with hydrocephalus is likely to have rickets or to develop tuberculosis. The hydrocephalic idiot, as a rule, is dull and somnolent, is liable to attacks of vomiting and to convulsive seizures, and sooner or later is apt to develop paralysis. In such a condition, one is justified in taking considerable risk, if the risk taken promises even the possibility of relief. The various operations that are performed for hydrocephalus are described in the section on Cranial Surgery.

Operations for Epileptic Insanity.—The conditions that call for operation on an insane epileptic are the same as those calling for it on a sane epileptic. It is occasionally justifiable to perform an operation if there has been an injury of the head, and an operation may lessen the number and diminish the violence of the convulsive seizures. Focal seizures demand operation, just as do focal seizures in the sane. In the status epilepticus operation may be performed to relieve pressure. Operation in epileptic insanity is performed for the convulsions, and not for the insanity.

Operations for Paresis.—A number of surgeons have operated for paresis; and, if we believe in the condition known as traumatic paresis, we may find some justification for the procedure. I do not advocate operation in paresis. I do not believe that a genuine case of paresis is ever cured. The lesions of the disease are irremovable and wide-spread; the brain, the medulla, and even the spinal cord, may be diseased.

Operations for Non-traumatic Insanity and Paranoia.—Operation cannot effect cure in such cases, and is not to be advised. In these cases there is no demonstrable causative organic lesion in the brain. Among such conditions are mania, melancholia, primary confusional insanity, stuporous insanity, and secondary dementia. Although we should not operate on these cases with any hope of curing the insanity, we may be driven to perform operation by the existence of symptoms indicative of local brain trouble.

Operations for Hypochondriacal Delusions.—It is always to be remembered that a delusion regarding a particular part is no proof whatever that there is a disease of that part. Sometimes a delusion has a visceral basis; but even if it has a visceral basis, this is no evidence that the insanity is due to the visceral disease. In hypochondriacal insanity there is apt to be a morbid concentration of the attention on some particular part. A patient studies a series of sensations and magnifies them, becoming convinced that he suffers from some dreadful condition in that region. A region of disease may occasion harassing sensations. The removal of such a region of disease may remove or alter the sensations, but it cannot cure a morbid mind; because a delusion results from the insanity, and does not cause it. Many of these cases have been operated on, and careful observers have found that the only effect is to shift the attention to another region. I have never seen the slightest improvement in the mental condition brought about by any procedure seeking to remove the sensations that had anchored the attention. As I have stated elsewhere,[21] all such attempts partake of the sort of wisdom which would lead one to tinker a weather-vane in hope of altering the wind, or to attack a thermometer in order to regulate the temperature.

Operations for Hallucinations.—It was suggested by Burckhardt that we should operate on patients suffering from very distressing hallucinations. In some cases he believes in removing the special sense-centers; in others, in dividing the fibers of communication between the centers. For instance, he excised the verbal auditory center for hallucinations of hearing; and asserts that the result was a diminution in hallucinations and a distinct improvement in the mental condition. This is an entirely theoretic operation, which assumes to know positively the seat of hallucinations. It is extremely probable that insane hallucinations arise in the cortex, but we must remember that they may be due merely to an excessive blood-supply, and that they may arise as the result of simple intoxication. I regard this procedure as entirely unjustifiable.

Operations for Traumatic Insanity.—A psychosis that has arisen as the result of a traumatic neurosis does not call for operation. The cases that may call for it are those in which the insanity results directly from the traumatism. The patient may become insane at once, or soon after an injury; but the insanity is often not recognized for weeks, or perhaps for months. Nearly all the victims of traumatic insanity are of the type predisposed to mental disease, the injury having been the exciting cause. It is estimated by some observers that traumatism is the cause in about 2 per cent. of the cases.

I have recently considered the subject of traumatic insanity at some length,[21] and I can best express my views by quoting from this paper:

"An antecedent injury may have directly induced the alienation; it may have had no bearing at all upon the latter; or it may have produced an insanity by fear and shock, and not by creating a direct brain-lesion. Again, the head-injury, by increasing the individual's susceptibility to alcohol and to the effects of the sun, may, if this person drinks alcohol or exposes himself to the rays of the sun, be indirectly responsible for the lunacy.

"In insanity following an injury to the head there may be various supposed causative lesions: a fracture of the skull, with or without depression; the development of an exostosis; sclerosis or softening of the cortex; edema of the membranes or of the brain itself; cerebral hyperemia or congestion; thickening of the membranes; adhesions of the membranes to the skull, to each other, or to the brain; a new-growth;

inflammation of the membranes; or minute, slowly developing, widespread, nutritive changes. The injury may be assumed to be the cause of the insanity, if the insane condition becomes manifest almost at once or soon after the accident; but if the symptoms do not appear until long after the accident, the traumatism may be considered to be the directly exciting cause in some cases, and not in others. It may be blamed if, between the time of the accident and the appearance of the insanity, there has been a marked change in the patient's disposition, temperament, or character; if he has developed headache, insomnia, irritability, passionate outbreaks of temper, moodiness, or lapses of memory; if he has plunged into immorality or excesses in alcohol; if he has displayed a tendency to neglect business or family obligations; and if he has shown increased susceptibility to alcohol and to the sun. Sometimes epilepsy may develop during this period. If there have been none of these intermediate changes in the normal mode of thinking and way of acting, one cannot count the traumatism as causative. Many persons who have received severe head-injuries have shown these changes, but have never gone insane. I have been studying this point for a number of years, and have decided that quite a few patients that have been trephined for fracture or for meningeal hemorrhage have subsequently shown pronounced and permanent changes in character and disposition. Of the number that show such changes, many never go insane, but some do. Such an insanity is distinctly traumatic in origin. . . .

"Various forms of insanity may be developed by traumatism: automatism, stuporous insanity, mania with acute hallucinations and violent outbreaks, melancholia, paranoia, and organic dementia. Sometimes in a middle-aged or even in a young person, the traumatism will be followed by a condition that seems to be identical with senile dementia. Traumatism may also induce a condition that closely resembles paresis, and some observers—notably Mickle—believe that it may induce genuine paresis.

"Does traumatism produce any special type of insanity? I have never been able to persuade myself that it does. Clouston thinks that there is a special type, and maintains that typical cases have headache, vivid hallucinations, and motor symptoms (convulsions, slight hemiplegia, and speech disorder); and that the mental condition is marked by irritability and impulsiveness, with advancing dementia or fixed delusions.

"The prognosis of traumatic insanity is bad. Some patients get well after operation; others recover without operation. In some cases in which recovery followed trephining, no causative lesion was disclosed by the operation. Some of the cases operated upon, in which supposed causative lesions have been removed, have not recovered. That an operation sometimes cures, by removing a lesion, seems proved; for instance, by elevating a depressed portion of bone. This was demonstrated by Skae's[22] celebrated case. Operation sometimes cures indirectly, by the effect of shock, etc.; and cure following an operation is sometimes merely a coincidence.

"In which cases should operation be performed? In a case in which insanity has soon followed a head injury; if the site of the trauma is indicated by a scar, a depression of bone, local tenderness, fixed headache, or some localizing symptom,—motor or sensory,—operation should positively be undertaken. In a case in which the insanity has developed later, in which the intermediate period between the injury and the development of the insanity has shown the change from the normal mode of thinking and way of acting previously alluded to, and in which the site of trauma is indicated by any of the evidences mentioned above —operation should positively be performed. One should not operate upon a case simply because there is a dubious record of an antecedent fall or blow, which merely suggests the possibility of a traumatic origin for the insanity. In any case in which there are positive signs of increased pressure it may be considered proper to trephine as a palliative measure."

Abdominal, Gynecologic, and Genito-urinary Operations.—It has long been maintained that there is a distinct sympathy between the pelvic organs and the mind of a woman; and it is some such thought that is at the basis of the doctrine that pelvic disease causes insanity, and that the cure of the pelvic disease may cure the insanity. Beyond any doubt, if an insane person has a disease dangerous to life, or producing pain or harassment or bad health, that patient is entitled to be cured or improved by a surgical operation; and it is equally certain that by the removal of some disease that has caused pain or harassment or ill health, there may be great improvement in the patient's general condition, and, consequently, great improvement in the mental health. Thus, an operation upon the pelvis may indirectly benefit the mental condition of an insane woman; but it does not do so directly. It is perfectly justifiable to operate for pelvic disease; but it is entirely unjustifiable to do such an operation as oöphorectomy upon an insane woman if the condition of the ovaries would not call for it in a sane woman.

Hobbes has warmly advocated operating upon the insane. Of 211 insane women whom he examined, he found that 179 exhibited well-marked evidences of pelvic disease. He operated upon 116 of these, with 2 deaths. Ninety-eight had tubal and ovarian disease, inflammatory in character; 51 per cent. of these were restored to mental health, and 7 per cent. were distinctly improved mentally. The group of non-inflammatory troubles included perineal lacerations, uterine displacements, tumors, etc. There were 70 non-inflammatory cases; 25.5 per cent. regained mental health, and 31 per cent. were improved. Of the 112 recoveries, 51 of the patients had been insane for two years. These figures are extraordinarily favorable.

At the meeting of the British Medical Association at Montreal in 1897, Rohe, of Maryland, reported 34 gynecologic operations. Eleven of these cases were cured mentally, and 9 were improved. Le Roy Brown comments upon the high percentage of cure obtained by Rohe and Hobbes, pointing out that Rohe believes that in patients in whom the delusions are aggravated by menstruation removal of the adnexa, whether diseased or not, should be practised; and that Hobbes makes an examination under ether, in order to determine whether the ovaries are healthy, and removes them, if they have even some minor disease. Brown goes on to say that these radical views have not been accepted, either by surgeons or by alienists; and he condemns the removal of normal ovaries or of those that are only slightly diseased.

There seems to be no doubt that there is a high percentage of pelvic disease among insane women; and when disease exists, an operation should be performed, if the patient's condition in other respects justifies it. Brown operates upon patients with pelvic disease if he thinks they will be physically benefited by operation; and the operations performed by him have not been done with the direct view of favorably affecting the mental disease. Many of the patients operated upon by him had forms of mental disease in which there was practically no hope of mental amelioration. Many others were markedly improved mentally after the operation, and in some of them it seemed certain that the improved general condition had hastened the mental recovery. This observer operated upon 242 patients, of whom 138 still remain in the institution and 104 have been discharged. Of the discharged cases, 43 are recorded as cured; and 20 of the 43 discharged as cured had their recovery materially hastened as the result of the physical improvement due to the operation.

Of operations upon the male genito-urinary organs, and of operations upon the larynx and upon the nose, we must maintain the same views. Such operations are to be done on the insane for the saving of life, for the improvement of health, or for securing the physical comfort of the individual; and such operations may occasionally act indirectly in improving the mental condition.

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CHAPTER XXXV.

SURGERY OF THE SPINE.

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ANATOMIC AND PATHOLOGIC CONSIDERATIONS RELATING TO THE SPINAL CORD.

The **spinal cord** is suspended and steadied within the dura by the nerve-roots and the connective-tissue septa (ligamenta denticulata) connecting the dura with the pia at the sides and by cerebrospinal fluid. The cord extends from the origin of the first cervical nerve, opposite the upper border of the arch of the atlas, to the tip of the conus medullaris, opposite the upper end of the second lumbar vertebra. Between these limits it is divided into segments corresponding to the origin of the nerve-roots. The clinical observation and diagnosis of cord lesions is made with reference to these cord segments, hence we must have an exact knowledge of the position of the segments with reference to the vertebral spines, our best or only landmarks of the spine. This is shown in Fig. 561.

It is to be remembered that the nerve-roots run downward within the canal for a varying distance before emerging at the intervertebral foramina. In their intraspinal course they are subject to injury by compression and otherwise, and usually give rise to the first symptoms (nerve-root symptoms) in intraspinal tumors, etc. As they possess many of the characters of peripheral nerves they resist injury from contusions and crushes much more than the soft cord. After entering the cord they may pass upward a short distance before reaching their centers in the cornua of the gray matter. It is therefore possible that a lesion pressing on the nerve-roots may be referred to a segment higher than the actual lesion, but in cord lesions in general there is more danger of the opposite error.

It is to be noted that the nerve-roots, and hence, of course, the spinal segments, do not correspond to a single peripheral nerve but to parts of several. The individual muscles usually receive fibers from the segments above and below the segment of the principal supply. The muscular innervation according to the segments of the cord is shown in the table (page 866). Hence a complete paralysis with atrophy and the reaction of degeneration of the muscles indicates an extensive cord lesion. Sherrington has also shown that the sensory areas overlap one another so that a given area receives innervation from the neighboring segments and retains a certain amount of sensation after destruction of its main root. At least three adjoining roots or segments must be destroyed to render a muscle or a cutaneous area, supplied by the middle one, completely paralyzed or anesthetic. The sensory area of each segment is not indicated by the area supplied by any peripheral nerve. Thus in the trunk these sensory areas are almost horizontal, whereas the nerves follow the obliquity of the ribs. The sensory area of the spinal segments is represented diagrammatically in Fig. 560.

The fibers of the anterior or motor nerve-roots enter the cells of the anterior horn of gray matter and then communicate by the motor tracts of the cord with the cortical cerebral centers. The fibers of the posterior or sensory roots pass in part into the posterior horn of gray matter, in part into the sensory tracts of the cord (posterior columns), while some fibers cross to the posterior horn of the opposite side and others pass to the anterior horn. The nerves (sensory and motor) and nerve-roots with the gray matter connecting the latter form the "reflex arc." If this is interrupted in any part, the reflexes of the parts involved will be lost.

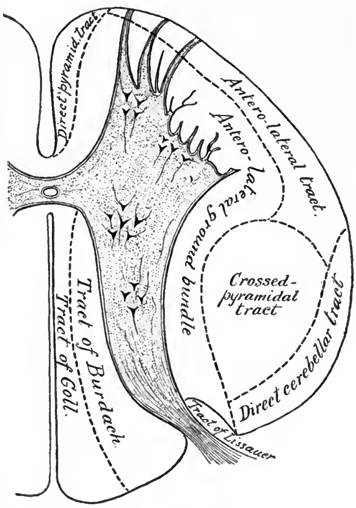

Fig. 553.—Transverse Section of Cord, Showing Tracts.

The peripheral part of the cord is made up of "tracts" or fasciculi of fibers composing the anterolateral and posterior white columns, which comprise both descending and ascending tracts. The former, motor in function, connect the cerebral motor centers with the anterior roots through the cells of the anterior horn of gray matter. The descending or motor tracts are (1) the crossed pyramidal tracts in the posterior part of the lateral columns, the fibers of which have crossed in the pyramids of the medulla, having come from the cerebral cortical centers of the opposite side; (2) the direct pyramidal tracts (columns of Türck), which lie in the anterior columns, on either side of the anteromedian fissure, and convey fibers from the same side of the cerebrum, which cross in the anterior commissure to the opposite anterior horn. The latter tract extends only into the mid-dorsal region and contains about 10 per cent. of the motor fibers.

The ascending or sensory tracts are principally the direct cerebellar and Gowers' tracts in the superficial part of the lateral columns, and Goll's and Burdach's tracts in the posterior columns. The former two pass up in part to the cerebellum; the tract of Goll and some of the fibers of Burdach's tract pass up to the medulla. The fibers of Goll's tract convey muscle-sense and the sense of coördination, and cross in the medulla. Those of Burdach's tract contain fibers which convey in part the sense of touch and pain. This tract is also a pathway for other sensory fibers, so that when diseased there may be anesthesia, pain, ataxia, and loss of reflexes. These fibers of Burdach's tract cross at once to the opposite side. Those of Gowers' tract (anterolateral ascending tract) convey sensations of pain and temperature and have crossed through the anterior commissure. The direct cerebellar tract conveys impulses to the cerebellum which help in maintaining equilibrium. The rest of the white substance of the cord, together with part of Burdach's tract, contains association fibers which connect varying levels of gray matter or, entering with the posterior roots, pass up or down a certain distance before entering the gray matter.

In addition, there are certain groups of cells and fibers in the gray matter of the cord which preside over certain functions and are known as "spinal automatic centers." The ciliospinal center, whose stimulation causes the pupil to contract, extends from the sixth cervical to the third thoracic segment, and its fibers leave the cord with the eighth cervical and first thoracic roots to join the sympathetic. The genital centers for erection and ejaculation are found in the first three sacral segments, those of the bladder and rectum in the fourth and fifth sacral segments (that of the bladder perhaps a little the lower), and the spinal vasomotor centers extend from the second thoracic to the second lumbar segments.

The nerve-cells of the anterior horn of gray matter are the trophic centers of the motor roots and nerve-fibers. Destruction of these cells is followed by degeneration, the reaction of degeneration, and finally the absence of all electric reaction in the nerve-fibers arising from them. Rapid atrophy of the muscles supplied by these fibers also follows. In addition, the deep reflexes of the corresponding parts are lost, as the reflex arc is broken. The paralysis at this level is flaccid (peripheral neuron paralysis).

After interruption of the pyramidal tracts alone the paralysis is spastic (central neuron paralysis), for the deep reflexes are preserved and exaggerated, as the reflex arc is intact and the inhibitory fibers are cut off. There is also no reaction of degeneration or trophic atrophy.

The trophic centers for the sensory fibers are in the ganglia of the posterior roots. The fibers of both the anterior and posterior roots have a neurilemma sheath outside of the cord, hence they are capable of regeneration. After section of the posterior root between the cord and the ganglion of the root all sensory functions of that root are destroyed and degeneration occurs only centrally, from the point of section into the cord, *i. e.*, in the segment cut off from the trophic cells in the ganglion. After section of an anterior root, degeneration occurs peripherally to the end of the nerve; the short portion in connection with the trophic cells of the anterior horn does not degenerate.

When the nerve-elements of the cord are destroyed they never reunite, for regeneration does not occur in the fibers of the cord, a fact apparently associated with the absence of a neurilemma sheath. Hence the uselessness of attempts to suture the cord. It should be mentioned, however, that Harte and Stewart[1a] have reported a case of division of the cord by bullet wound, treated by immediate suture, in which there has been some return of function. In a few other cases suture of the cord has been done,[1b] but the reports are mostly so incomplete that it is hard to form an opinion, or else the results have been negative. More and accurate clinical proof is required to disprove that suture of the cord is useless.

In partial injuries and compression of the cord the outer portion or the conducting white tracts are first affected. While, as a rule, this is true, in some cases of compression as well as partial crushes the central gray matter may show signs of injury (dissociated anesthesia), while the overlying conducting tracts are mostly normal. The gray matter is softer and more easily injured, though better protected, than the white columns. In overstretching of the cord the gray matter is the particular seat of the lesion. In chronic compression the nerve-roots may be the first to show the effects of pressure by pain in the area of their sensory distribution.

The symptoms of cord lesions vary with the part of the cord first or most injured or compressed; hence the importance of a knowledge of the tracts of the cord and their function.

In partial lesions of the cord the loss of conductivity of the white tracts will result in spastic paralysis of the muscles supplied by nerves arising below the lesion on the same side, and loss of muscle sense on the same side, and of the other forms of sensation (touch, pain, and temperature) on the opposite side, for the fibers of the latter cross in the cord. The reflexes are usually exaggerated. For the results of lesions of the anterior horn of gray matter see page 818. In one or two weeks the motor paralysis begins to disappear, from the recovery of those fibers which have not been destroyed, and perhaps owing to fibers in the uninjured half of the cord, like the direct pyramidal tract, which serves as a reserve. Such a double innervation of muscles is limited, according to Wernicke and Mann, to the extensors of the thigh and knee and the plantar flexors of the foot. Hyperesthesia occurs in the injured side and sometimes painful paresthesia.

The presence of the above and other symptoms depends on the position and extent of the lesion, and this variation in symptoms helps in the diagnosis. In partial lesions due to pressure on the cord the motor tracts suffer more than and before the sensory, and, according to Horsley, the invasion of the paralysis is from above downward, being the reverse of that of anesthesia.

In complete transverse lesions of the cord there is complete motor and sensory paralysis of the parts supplied by nerves arising below the level of the lesion. The paralysis is flaccid and the tendon reflexes are almost always lost, though theoretically we would expect the reverse, for the reflex arc is not interrupted. There is no reaction of degeneration and no atrophy, except that due to disuse. The vasomotor centers are paralyzed, resulting in increased warmth of the surface, anemia of the viscera, and priapism. In addition, the sensation and voluntary control of the bladder and rectum are lost and there is a marked tendency to decubitus.

When a lesion which has caused gradual compression is removed, the symptoms gradually disappear if and so far as no degenerative changes have occurred. The soft consistence of the cord renders it very susceptible to injury by contusion. It may be severely or even completely crushed while its shape is retained by its membranes.

The *cauda equina* is formed by the nerve-roots of the lumbar and sacral segments, the last three sacral segments at the tapering end of the cord being known as the conus medullaris. While the lumbar and sacral segments are crowded into a length of cord not exceeding $3\frac{1}{2}$ or 4 inches, the sacral roots have an intraspinal course of 5 to 6 inches. The cauda is inclosed by the dura as by a muff, and the roots composing it pierce the dura opposite the foramina by which they emerge. It covers and completely conceals the lower end of the cord, so that no injury to the lumbosacral region can occur without an injury to the cauda, and the latter may also be injured alone below the level of the cord. After injury to the cauda the loss of function may be the same as after injury to the lumbosacral cord alone.

The lower roots of the cauda are the more internal, but in injuries and compression of the cauda these roots are more seriously affected by the pressure than the upper and more external roots. (Cf. also Chapter XXXI.)

For a more detailed description of the pathology of these lesions see Chapter XXXI.

CONGENITAL DEFORMITIES.

Spina Bifida (Hydrorrhachis).—This congenital defect of development involves a cleft or defect of one or more of the neural arches with the protrusion of a hernia-like sac formed by some of the spinal membranes with or without the cord or nerve-roots. It occurs about once in 1000 births (Wernitz).

Its **etiology** is unknown. Amniotic bands and local inflammatory processes (Virchow); disproportion between the growth of the canal and the cord (v. Recklinghausen); imperfect separation of the skin and medulla (Marchand, Ranke), have all been suggested to explain the defect. The latter is the most satisfactory explanation.

In the embryo the epiblastic medullary ridges come together to complete the medullary tube and its central canal. The epidermis is thus completed across the middle line and is soon separated from the medulla by the extension between them of mesoblastic tissue which forms the meninges, vertebræ, muscles, and fibrous structures. The neural arches of the vertebræ are completed posteriorly by the growing together and fusion in the median line of the two laminæ, each of which is ossified from a separate center. This fusion commences in the upper dorsal region and extends in both directions. Its failure causes a median posterior defect which is most common at the lower part of the spine, which closes last. In very rare instances the protrusion takes place through a lateral or anterior defect.

Varieties and Pathology.—The defect may be confined to one arch, often it involves several, and rarely all. *Rachischisis* is a complete absence of union of the walls of the medullary canal. This may be complete, involving its entire length, or partial and limited to a few vertebræ, usually in the lumbar region. The scanty remnants of the cord are seen as a reddish-brown velvet-like band on the pia along a groove in the median line uncovered by epidermis (zona medullovasculosa). On either side of this the pia is covered with epithelium from the laterally adjoining skin, giving it the appearance of a fresh scar (zona epithelioserosa). The dura and pia become lost in the adjoining normal skin. In partial rachischisis the zona medullovasculosa shows a dimple at either end, which indicates the entrance to the central canal above and below. The subarachnoid space is found beneath the pia, and if this contains an increased quantity of fluid a tumor is formed, on the dorsal wall of which the zona medullovasculosa, etc., runs longitudinally. This forms the myelomeningocele of v. Recklinghausen, the sac of which is lined by the pia whose inner surface is outside. The above varieties have in common a defect in the skin which serves as a starting-point for inflammation, by the extension of which a fatal meningitis is caused. In these forms there is a lack of development or secondary destruction of the cord, causing paralysis of the legs and sphincters, and there are often other associated clefts or defects of the abdominal wall, skull, bladder, etc. Hence such infants are rarely, if ever, viable and many are still-born.

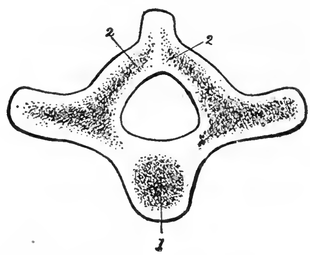

Fig. 554.—Ossification of Vertebra (Testut).
1, Median point for the body (centrum); 2, 2, for the neural arches.

The epidermis always unites if the medullary canal closes, though the mesodermic tissues may present defects. A cleft in the dura usually accompanies one in the bone, but the pia and arachnoid are always closed if the cord in its development has formed a central canal.

There is much confusion in the nomenclature and the pathologic description of the varieties of spina bifida proper. Three forms are usually described: (1) Spinal meningocele, (2) myelomeningocele, also called meningomyelocele, and (3) myelocystocele (syringomyelocele). The latter variety may be combined with meningocele (myelocystomeningocele).

These forms have in common a cleft of the bony canal, and hence of the dura, as a rule. Rarely a meningocele may protrude between two normal arches, in which case the opening often becomes closed, so that the sac no longer communicates with the subarachnoid space. The cleft in meningoceles is usually small and a little to one side of the median line; in myelomeningoceles large, involving four or five or more vertebræ; and in myelocystoceles small, involving one, two, or three vertebræ, and comparatively narrow in simple cases.

In *meningoceles* there is a hernial protrusion of the arachnoid in which the fluid collects, distending it so as to form a single globular cavity, often of large size. The pedicle is slender and the skin covering is usually normal. According to some, the cavity is traversed in complicated cases by nerve-roots which may be adherent to the wall of the sac. Others class as meningoceles only those tumors which contain no nervous elements.

Myelomeningoceles have a sac with a wide base and a somewhat flattened contour, often subdivided by partitions. Nerve-roots, the flattened cord, or the cauda equina are usually attached to and spread out over the dorsomedian aspect of the sac. An umbilication of the summit shows externally the attachment of the cord. The nerve-roots run in long loops to reach their intervertebral foramina and may show plainly through the walls, which are thin and appear membranous over the summit and sides. Over the summit, particularly, superficial granulating ulcers are frequently found.

In myelocystoceles (syringomyeloceles) fluid accumulates in the central canal and distends it and the overlying substance of the cord so that this becomes atrophied, especially its dorsal portion. The latter may be reduced to a layer of pia with few remnants of nerve elements. The skin covering the tumor is often very thin. It is separated from the sac by the loose tissue of the arachnoid, and frequently the skin and sac are closely adherent from the effect of pressure, inflammatory changes, etc. Circumscribed losses of the epidermis are apt to occur and may deepen and perforate the sac. The sac does not contain nerves, as it is a distended central canal. This variety is often combined with deformities of the spine, abdomen, feet, etc. In combinations of myelocystocele with meningocele (myelocysto-meningocele) the latter tumor may be on the ventral or dorsal surface of the former or on both.

The fluid in all the forms is cerebrospinal fluid. Myelomeningoceles are considered the most common form, but Muscatello[2] regards meningocele as the commonest form. Spina bifida may occur in any region of the spine, but is much more common in the lumbar and sacral regions.

Symptoms.—While many meningoceles give no symptoms apart from the presence of the tumor, in other cases of spina bifida there is more or less paralysis of the bladder or rectum or both, often combined with varying degrees of paralysis and sensory disturbances of the lower extremities. Other abnormal conditions may also be present, especially hydrocephalus, club-foot, or defects elsewhere. Not infrequently the bony cleft cannot be felt, owing to the size or tension of the tumor or the amount of the surrounding fatty tissue, but in such cases it can be shown by the *x*-ray, except perhaps in very young subjects.

Diagnosis.—The congenital origin and the position of the tumor filled with fluid, whose tension varies with posture and expiratory efforts (crying, coughing, etc.), render the diagnosis easy. The differential diagnosis between the several varieties is of great importance for the prognosis and treatment. The differences are great enough to allow a shrewd guess, but often it is not possible to diagnose the variety until after incision. The complete clefts, rachischisis, and the open form of myelomeningoceles, are readily distinguished by the defect in the skin. The diagnosis between the varieties of spina bifida proper is more difficult.

In differentiating meningoceles from myelocystoceles we notice in the latter that a more decided and prompt swelling of the fontanels follows pressure on the tumor, that there are often marked sensory disturbances in the lower extremities, that the overlying skin may show ulcerations or their scars, and that paraplegia, paralysis of the sphincters, and other deformities are more often present. Meningoceles are almost always over the sacrum and present the smallest pedicles and bony clefts. Nerve-roots traversing the tumor or adherent to the wall can sometimes be seen in the complicated forms with thin walls. On opening the sac the presence of nerve-trunks in a cavity lined by a shining membrane indicates that one has opened a meningeal sac (meningocele). Absence of all signs except the local ones is most common in meningoceles. Clinically they are to be differentiated from myelomeningoceles by the broad base and irregular and often umbilicated form of the tumor and the thin and often ulcerated covering in the latter. In these tumors also the presence of the cord and nerves in the wall of the sac, as well as of septa subdividing the cavity, may be inferred from shadows seen in examining the illuminated sac. The presence of other deformities and of paraplegia helps to distinguish myelomeningoceles from meningoceles.

The **prognosis** in general is unfavorable. Most cases fortunately die early. Of 649 children that died of spina bifida in England in 1882, 612 died within the first year. Among 90 cases not operated upon, the majority died within the first few weeks; only 20 lived to be over five years of age. Usually the tumor increases in size; the skin is then liable to ulcerate, leading to perforation of the sac, infection of the meninges, and death. Very rarely rupture is followed by spontaneous cure. When the sac connects freely with the ventricles of the brain, sudden evacuation may be quickly fatal. If the first few weeks of life are survived, paralysis of the bladder with the constant danger of urinary sepsis always threatens life. Most cases living five years or more are meningoceles.

The prognosis of the complete clefts and the open myelomeningoceles of v. Recklinghausen is usually absolutely unfavorable. The prognosis is most favorable in meningoceles, next in myelocystoceles. Many cases surviving radical treatment die of hydrocephalus or of the secondary effects of existing paralyses.

Treatment.—In many cases nothing but palliative treatment is indicated. The condition present is incompatible with life, and death occurs during the first few weeks. Pressure to prevent increase in size should be used with caution, if at all, and only when the skin is normal, owing to the liability to ulceration. The surface should be kept clean and dry and protected by cotton or smeared with sterile vaselin. Palliative aspiration, to diminish the pressure and the danger of rupture, may be employed in cases when the spina bifida is suitable for radical operation later on. The needle should be introduced obliquely where the coverings are thickest, usually near the base and at the side, to avoid injury to the nerve elements, and the patient should be kept recumbent. Aspiration alone is useless, and if frequently repeated is eventually fatal. If rupture occurs, immediate excision and suture should be done to avoid infection. Aspiration of a dram or two of fluid, followed by gradual injection of one-half to one dram of Morton's fluid (iodin gr. x, iodid of potassium gr. xxx, glycerin oz. j), may occasionally be employed when open operation is contraindicated. This requires repetition every ten days for two or more times in cases where a cure is finally effected. Among the 71 cases treated by this method in the report of the London Clinical Society,[3] 35 were cured, 4 improved, 5 not improved, and 27 died—a mortality of 38 per cent. Morton's own statistics showed a smaller mortality, 15.3 per cent. The cure results from the adhesion of the sac walls due to the inflammatory reaction.

At present open operation is almost exclusively used. Opinions differ as to its contraindications, the age at which to operate, and the operability of the various forms. Hydrocephalus, marked paralyses or loss of sphincteric control, and irreparable deformities elsewhere are considered contraindications by most surgeons. Improvement or even cure has, however, occasionally followed operation, even where there was paresis of the bladder or lower extremities. If by operation it is possible to improve or cure cases presenting moderate paralytic symptoms, it would be justifiable, for without operation they either die from the secondary effects of the paralyses or, if they live, the life is not worth living. An unfavorable result from the operation is no worse than is to be expected without operation.

Of course, the secondary disturbances, paralysis of the sphincters or lower extremities, are not influenced if they depend upon a fetal defect of the cord, but they may be due to pressure within the tumor.[4]

As to the age, Sachtleben[5] advises operation as early as possible; others advise waiting two or three months or longer, for improvement in general or local symptoms; Broca[6] advises waiting several years, and Moore[7] suggests five years. In view of the early mortality (page 823), if we operate to save life and improve the symptoms the operation should be done during the first year. Those cases which live to the fifth year or over are the favorable ones where we could wait from month to month until of a suitable age for operation. Many cases we would not operate on anyway, and most of these die in the first weeks. The mortality is higher in operations done in the first few months, 35 + per cent.,[7] against 4.7 per cent. in those five years old and over. This simply means that by waiting natural causes have produced the mortality, part of which might have been attributed to surgery, and the latter has lost the opportunity of curing or improving some cases. There is little or no hope of improving the paralysis when it has lasted for several years, so that a late operation has no effect but the removal of the tumor.

As to the operability of the various forms, rachischisis and the open form of myelomeningocele are generally considered inoperable.

Meningoceles are the most favorable for operation.

Opinion is divided as to the propriety of operating on myelomeningoceles and myelocystoceles. In the majority of cases operation may be regarded as hopeless, as most cases of myelomeningoceles die of septic meningitis, due to rupture or ulceration, or of hydrocephalus. Operation is justifiable to cure or prevent ulceration or rupture, but it has no favorable effect on the hydrocephalus. Lebrun[8] has reported a case of myelomeningocele in which the paresis of the lower extremities was entirely relieved by operation. If the nerve-roots run free in the sac the conditions are more favorable for operation.

Myelocystoceles are suitable for operation when the contraindications above given are not present and even in the presence of slight paralytic symptoms.[5] No operation should be done when these tumors have a thick covering of sound skin and are not enlarging rapidly. An ulceration of the overlying skin, though not absolutely contraindicating operation, is most commonly observed in cases with hydrocephalus which contraindicates operation.

Technic.—Chloroform anesthesia has been most often used. Asepsis is of the first importance. The hips should be somewhat elevated on a couple of hot-water bags to prevent the loss of heat and the too sudden or complete escape of cerebrospinal fluid. If necessary, leakage may be prevented by stuffing the canal with gauze.[4] The patient should lie prone or on one side, and some bind the patient to a board in the prone position.

The *skin,* if ulcerated, must be very carefully cleansed and the ulcerated area sterilized by pure carbolic acid followed by alcohol. The skin is redundant, so that some is removed, but the incision should be made so as to furnish sufficient flaps to meet without tension on one side of the median line. If the skin is ulcerated this area should be excised. If it is thin and adherent to the sac, as in large myelocystoceles and meningoceles, the incision should commence at one side, beyond this area, and it may be necessary to excise a considerable area of both skin and sac. In large myelocystoceles this may be done without increasing the paralysis. It is important to have the sac full while separating it from the skin.

In meningoceles the *sac* should be dissected out down to the pedicle and opened by a longitudinal incision, preferably on the side, and this gives a complete view of the interior of the sac, and the nerve-roots, if present, are more likely to run on the dorsal surface. Any nerve-roots present in the sac should be replaced in the vertebral groove, after being carefully dissected out if they are adherent to the inner surface of the sac. If this is very difficult, that part of the sac wall to which they are adherent may be returned to the vertebral groove with the nerves attached. Sometimes it may be best or necessary to sacrifice them, and not infrequently they are of no importance, for, according to Polaillon and Monod, the nerve-trunks which spread out over the wall of a lumbar or sacral spina bifida and do not return to the canal have nothing to do with the innervation of the lower extremities, except where the latter are paralyzed. Their function, however, may be tested by the faradic current. Schmidt[10] involutes the sac and makes it serve as a tampon for the opening. Otherwise the pedicle of the sac, after being freed within the bony cleft, should be ligated or sutured by one or two rows of absorbable sutures, with the internal surfaces in apposition.

In myelomeningoceles the sac is opened on the side, taking care to avoid injuring the cord or nerve-roots. If the latter are free and not adherent to the sac, this may be excised except where adherent to the cord. Otherwise the emptied sac is replaced in the groove and covered by flaps of muscle and aponeurosis and then by skin. In small myelocystoceles the sac is opened where it is thinnest, and evacuated, and then treated in the same way. In large myelocystoceles the thinned out dorsal part of the sac contains little or no nervous tissue and may be excised with the overlying thin skin. The rest of the sac is then treated in the way above described. If the cauda protrudes and is amputated, the ends should be carefully sutured.

Various devices have been employed to cover or close the bony defect to prevent the recurrence of the swelling. But there is little or no tendency to recurrence unless there is hydrocephalus or infection. In the former case operation is contraindicated and every effort should be made to avoid the latter. Hence Bayer's lateral flap of muscle and fascia which is inverted and sutured so as to cover the opening is sufficient for this purpose and to be recommended. Liberating lateral incisions through the aponeurosis may also be used to free lateral flaps, for this purpose. The simplest and quickest technic is the best in such cases, as it minimizes the danger of infection and the patients cannot stand a long operation. Thus, the fracture of the rudimentary arches and the suture of their free ends (Dollinger), the pedunculated flap of bone and periosteum from the sacrum (Selenko) or from the crest of the ilium (Bobroff), and the transplantation of bone and periosteum from animals (Robson and others) are not to be recommended. Finally, the skin is sutured after any redundancy is removed. This suture line should be to one side and not directly over that of the sac, which is naturally median and longitudinal. Hence the skin incision may be latent, but, as the skin is redundant, a median incision will allow of suture on the side on which excision of the skin is made. Drainage is unnecessary, if the operation has been aseptic, and unwise, as it favors infection; so, too, does the leakage of cerebrospinal fluid, which we should take care to avoid. If it occurs, it necessitates the greatest care in the dressings.

During the wound healing the greatest care should be taken by the nurse to prevent its soiling and infection by the discharges from the bowel or bladder. Celloidin or collodion applied over the inner dressing, or rubber tissue fastened over the dressing by adhesive plaster around the edge, combined with frequent change of napkins and outside dressings, will fulfil this requirement. Fastening the child prone on a board facilitates this, but it is not necessary to keep the child off its back altogether during the healing of the wound, and feeding is difficult in the prone position.

Results.—Sachtleben[5] reports 18 operations from Mikulicz's clinic, with satisfactory final results in 38.9 per cent. Of the 12 locally cured, only 5 were completely sound, and 6 died within the first year, leaving only 3 completely sound who were alive at that time. Schmidt[10] reports 18 per cent. of permanent cures from the clinics of v. Bergmann and König. Nicoll[11] reports a mortality of 21.8 per cent. from this operation among 32 cases. Moore[7] collected 385 cases treated by excision, among which the mortality of cases operated since 1885 was 24 per cent.; but of those surviving the operation a mortality of 7 per cent. was reported within the first three months. The opinion is expressed that if all cases had been followed and reported the total mortality a few months after operation would have been fully 50 per cent. The most frequent causes of death are shock, meningitis, and hydrocephalus. Deaths occurring some weeks or months after operation are generally due to late infection or to hydrocephalus, which is generally post-operative in its development. Muscatello[12] thinks that postoperative hydrocephalus appears especially in cases where there has been ulceration on the surface, and is the result of a form of infection causing meningitis diffusa serosa. Although it is true that, owing to the distressing nature of the affliction, the high mortality should not deter from attempts at surgical relief, yet it should also be remembered that few cases are reported in which paresis of the sphincters or lower limbs has been cured or improved by the operation. Hence, with few exceptions, about all that can be expected from operation is the relief of an annoying and unsightly tumor and the prevention of meningitis from rupture or ulceration.

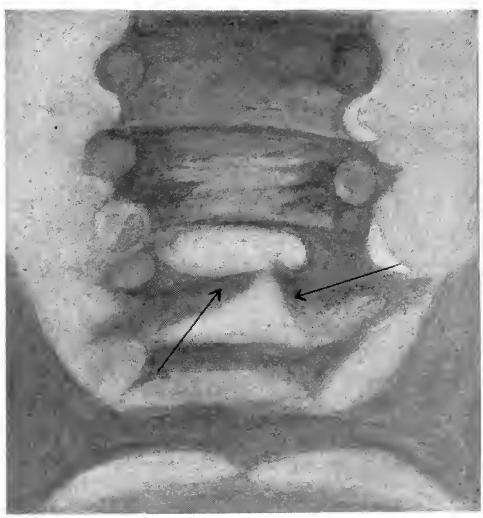

Fig. 555.—Skiagraph of Spina Bifida Occulta (Kellner).

Spina Bifida Occulta.—This form differs from the preceding in the absence of protrusion of the contents of the spinal canal. Etiologically it does not differ from the common form. The situation of the bony cleft, which is usually closed by a membrane and is found in the sacral or lumbar region, is indicated by a hairy patch which may be the only indication of an abnormality. The cleft can usually be felt, but in some cases in the lumbar region the *x*-ray may be of use to demonstrate it (Fig. 555). The hair has a characteristic concentric arrangement over the center of the defect. After puberty it may grow to 25 or 30 cm. in length and resemble a tail[12] (Fig. 556). Some hypertrichosis is common in all spinæ bifidæ. Cicatricial changes in the skin over the defect are common and are always present when tumors exist within the canal.[2] Tumors, such as lipomata and fibromata, and sometimes myomata, angiomata, dermoids, etc., are frequently found inside or outside the vertebral canal or occupying the bony cleft, in this variety of spina bifida, due to the growth of embryonal cells in the formation of the defect (Recklinghausen). If they present outside, they form a solid median tumor of the back; if they present inside, they in time cause symptoms of pressure on the cord. Even in the absence of such tumors attention may be called to the condition by sensory, trophic, or motor symptoms of pressure on the cord, especially its posterior part, such as areas of anesthesia, neuro-paralytic ulcers, also sometimes paralytic club-foot, partial paraplegia, and sphincteric paralysis, not otherwise easily accounted for. These symptoms often first develop during the period of greatest growth of this part of the body, *i. e.*, from the ninth to the seventeenth year, and the prognosis is more favorable than when they appear in early life. The explanation of these symptoms and of their occurrence at this time is to be found in the presence of a firm fibrous band passing through the cleft and connecting the skin over the cleft with the cord near its lower end. It represents an imperfect separation of the two in fetal life, and does not grow with the growth of the structure it connects. Hence it pulls and stretches the cord or presses it against the lower margin of the opening at the period when the body growth is at its maximum. Hence the treatment of this condition, when symptoms are present and are due to such bands, consists in incising or excising them. Good results from this treatment are reported by Katzenstein,[13] who cured bladder symptoms of six years' standing, Jones,[14] who cured a perforating ulcer of the foot, Milner,[15] and others. Where a tumor is present and causes pressure symptoms its removal is indicated. The many cases where there are no cord symptoms, and the fewer cases where such symptoms depend upon fetal defects of the cord and appear in early life or have lasted for years, should be let alone.

Fig. 556.—Trichiasis Lumbalis with Spina Bifida Occulta (Kellner).

Syringomyelia.—This disease depends upon the presence of one or several cavities in one or both posterior horns of the cord, and often communicating with the central canal, primarily, as a rule, in the cervical swelling, and extending thence down and up to various degrees.

In its classic manifestations the disease comes on insidiously, with aching or lancinating pain in the upper extremities and neck, and paresthesia of the hands. The characteristic symptoms of the disease are thermoanesthesia and analgesia, with almost perfect tactile sensibility; progressive muscular atrophy and weakness of the hands, gradually extending to the trunk; vasomotor and trophic disturbances, and scoliosis, generally in the dorsolumbar region. The legs are not involved until late, and then they may show spastic paraplegia, their reflexes being exaggerated, while those of the arms are lost. Occasionally there is some anesthesia. Besides the classic form, there are several other types of the disease.

The **diagnosis** is not always easy. Of the conditions treated in the present chapter it has been confounded with hematomyelia and intraspinal tumors. In fact, the cases operated on have been mistaken for spinal tumors. In Harte's table of 92 operations for intraspinal tumor there were 5 cases of syringomyelia, and Keen has reported another. Three of these died, two were improved, and one was unimproved. The prognosis is finally fatal, but the duration is very long. The medicinal treatment by arsenic and silver preparations has little or no effect and the character of the lesion suggests the possible utility of surgical treatment. Abbe[17] aspirated ℥iss of the fluid, so that the cyst collapsed, but with no ultimate improvement. Murphy[18] suggests the use of an non-absorbable seton, such as horsehair, leading from the central cavity to the subdural space, to insure permanent drainage and equalization of pressure, with a view to stop the advancement of the disease. The principle is the same as in the subdural drainage of cerebral hydrocephalus. In the many cases with multiple cavities this would have little effect. Laminectomy alone may have some effect in relieving pressure and pain[35] in certain cases with much enlargement. The surgical treatment of the disease is not at present one to be generally recommended.

ACUTE OSTEOMYELITIS OF THE SPINE.

Although not common, many cases have been recorded since 1900, when Hahn[71] collected 41 cases. Seventy-five per cent. of the cases are under twenty years of age. It is most common in the lumbar region (41 per cent.) and least common in the cervical. Any part of the vertebra may be attacked.

In Hahn's 41 cases traumatism was the undoubted cause in 6 cases and was present in 15. Staphylococci are usually the specific organisms present. Abscess usually results, but the process may resolve without pus formation, especially in subacute and typhoid cases.

The **symptoms** consist of (1) the general constitutional ones common to acute osteomyelitis in general (see Chap. XXIII), and (2) the local symptoms. Among the latter we may find local swelling after three to ten days, local tenderness on pressure and often on pressure in the longitudinal axis. After one to three weeks or more an abscess may form, the location of which varies with that of the osteomyelitic process. If the bodies of the vertebræ are involved, the abscess is usually prevertebral, *i. e.*, retropharyngeal, posterior mediastinal, psoas, etc. The abscess presents posteriorly if the arches are involved. Pyemic symptoms are likely to develop.

Extension to the spinal canal is the most important complication. In that case the pus may produce symptoms of pressure on the nerves or cord, or the inflammation may extend to the meninges or cord.

The **diagnosis** is made from the local symptoms mentioned above. The nerve symptoms may aid in localizing the lesion. A semi-comatose condition may make the examination and the diagnosis uncertain.

Prognosis.—The mortality is about 60 per cent. The prognosis is worse when the lumbar and lower dorsal regions are involved and when the process extends to the canal or involves the meninges or cord. It is better when the disease is recognized and can be operated on early, *i. e.*, when it is not in the bodies.

The **treatment** is early opening and drainage of the abscess by an incision behind the sternomastoid in the neck, by a retroperitoneal route in the lumbar region, and after excision of the ribs and transverse processes in the thoracic region. If sequestra are present they should be removed if possible. If they are in the vertebral bodies and of large size, this may present much difficulty. If there are signs of pus within the canal, this must be opened and the abscess drained. If it is intradural, the dura should be opened. When the bodies are involved the spine should be supported for some time during convalescence, as in Pott's disease.

CONGENITAL CYSTS AND TUMORS OF THE SACROCOCCYGEAL REGION.

Sacrococcygeal meningocele is due to the bulging of the dura through a cleft in the fibrous tissue between the cornua of the sacrum and coccyx, though normally the lower limit of the spinal membranes containing cerebrospinal fluid is opposite the third sacral vertebra. There is no bony cleft. It forms a cystic tumor beneath the skin. Lymphangioma, lipoma, and teratoma are occasionally found in connection with or surrounding such cysts.

Teratoma.—This is a growth of congenital origin composed of one or several tissues or organs which do not normally occur at the place where the tumor grows during that period of development at which it presents itself clinically. It may consist of a single tissue growing from a matrix displaced by inclusion or errors of development, such as the lumbosacral and coccygeal *lipomata.* These lipomata are sometimes observed at the seat of a spina bifida occulta, either without or within the vertebral canal. They may also contain nervous and epithelial structures. The origin of these tumors is in misplaced anlage (fetal nucleus), in connection with defect of development of the vertebral arches. Lipomata in the median line of the lumbosacral region are not uncommon. A mass of fat often overlies a spina bifida sac, so that the surgeon should be cautious in operating on supposed fatty tumors in the median line. These masses are not encapsulated and hence are not true lipomata.

Congenital lipomata also occur between the sacrum or coccyx and the rectum, which may have the same origin as the more complex tumors in this region. Middledorpf found in a small congenital lipoma of the coccygeal region a small convoluted loop of intestine.

Instead of a solid there may be a cystic tumor, such as *epidermoid and dermoid cysts.* These occur occasionally along the line of median coalescence posteriorly, being due to the fetal inclusion of dermal anlage. In the sacrococcygeal region they may be mistaken for or, rarely, associated with a spina bifida, increasing the difficulty of the diagnosis of both and making advisable an exploratory puncture before operating on a supposed dermoid cyst. A favorite situation for small dermoid cysts is at the junction of the sacrum and coccyx or at the post-anal dimple over the coccyx. They are apt to leave a blind fistulous tract after suppuration. In such cases the probe helps to determine the extent and location of these cysts if extirpation is practised.

Dermoid cysts of the space between the rectum and sacrum are not common. They are derived from that part of the neurenteric canal known as the post-anal gut. They may contain teeth as well as hair. In their growth they develop toward the pubes and press the uterus upward without spreading the broad ligaments. They are smooth and sharply outlined. These features serve to distinguish them from the ovarian dermoids and cysts.

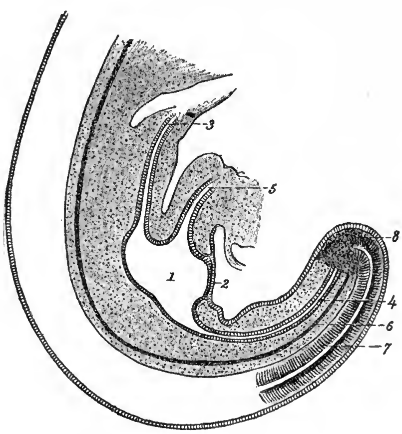

FIG. 557.—SAGITTAL SECTION OF CAUDAL EXTREMITY OF CAT EMBRYO OF 6 MM.

1, Cloaca, 2, cloacal membrane; 3, intestine; 4, post-anal gut; 5, allantoic canal; 6, chorda dorsalis; 7, medullary canal (Tourneux).

In a more narrow sense the term *teratoma* is applied to more complicated forms of cystic or solid tumors which contain tissues derived from two or all three of the germ layers. The terms sacrococcygeal tumor, thyroid-dermoid, congenital cystic sarcoma (Braune), and embryoma also refer to the same condition, though the latter term is often restricted to bigerminal tumors whose origin is connected with a second or parasitic fetus.

There is much diversity and confusion in the nomenclature and classification and in the description of the etiology and pathology of these congenital growths. Besides (1) simple and (2) compound dermoids Bergmann's classification includes (3) cystosarcomata, usually mixed tumors which cannot always be sharply distinguished from (2); and (4) subcutaneous parasites and implantation cysts. The compound dermoids may begin to increase rapidly in size at any time. In the cyst wall or solid growth of these sacrococcygeal tumors we may find a great variety of tissues or rudimentary organs, from the more or less perfect *fœtus in fœtu* to masses without orderly arrangement. It is still a matter of dispute as to whether they are derived in large part from the neurenteric canal (monogerminal) or are bigerminal and derived from a parasitic twin. In the fetus the lower end of the central canal of the spinal cord is continuous, around the caudal end of the notochord, with the lower end of the alimentary canal, which, lying behind the point where the anus meets it, is called the post-anal gut. This latter portion normally disappears at an early period, but under certain conditions takes on an excessive growth, with the production of sacrococcygeal cysts and tumors (teratoma). As the neurenteric canal represents an ectodermal canal becoming continuous with an entodermal one and surrounded by mesodermal tissue, it is easy to understand how these tumors may contain products of all three germinal layers. It is believed by many that this monogerminal explanation applies to the majority of such tumors, even many of the complex or mixed tumors. Englemann[19] admits the bigerminal origin of those tumors only in which true double forms, complete organs, are found, which do not belong to that part of the body. Almost all the organs of the body have been found in rudimentary form in these complex tumors. Other investigators hold that the bigerminal theory, which explains them as the imperfect growth of an implanted second or parasitic ovum, accounts for all the complex and mixed tumors.[20]

Clinically they form tumors of varying size. They may be very prominent at birth or cause little or no external swelling for a time at least. In such cases they may be first discovered on making a rectal or vaginal examination, to determine the cause of constipation, etc. Or the dermoid cysts may suppurate and be at first mistaken for an ischiorectal abscess or fistula, the true nature of the condition being first discovered on operation. In a recent case of ischiorectal fistula, alternately closed and open for years, eleven rather small dermoid cysts were removed from behind the rectum. The larger sacrococcygeal tumors develop forward toward the pelvis and downward between the legs, displacing the anus and then the genitals forward and downward. They never extend in the upward direction above the postero-superior margin of the gluteal muscles. I have seen one case where the tumor was so large (10 pounds) that until removed it prevented the patient, a man of thirty-four, from wearing trousers.[21] They often interfere with the sitting posture.

The **caudal appendages** need only be mentioned. True tails, when *complete*, would contain supernumerary coccygeal vertebræ. No case has been reported. Imperfect true tails may contain muscle, nerves, vessels, and fat, and may be mobile. They are directly continuous with the coccygeal vertebræ. The most common forms are the tail-like appendages of skin containing more or less fat. Sacrococcygeal tumors or tufts of hair covering a spina bifida occulta are sometimes reported as tails.

The **prognosis** of coccygeal tumors is doubtful only in compound dermoids and cystosarcomata, because they, especially the latter, may grow rapidly.

Treatment.—This is entirely surgical, and depends somewhat upon the variety, size, and position of the tumor. Removal is indicated on account of rapidity of growth, large size, the mere disfigurement of the growth, suppuration, and to prevent the latter. Such as are growing rapidly should be removed as soon as possible. The large size is an indication for operation because it prevents an easy sitting posture or the wearing of ordinary clothes, and causes discomfort by crowding the coccyx backward and the rectum and pelvic organs forward. As they are encapsulated, they should be shelled out if possible. Only when they extend well up into the pelvis in front of the sacrum is there much difficulty. Here it may be necessary to resect the coccyx or even the lower part of the sacrum to reach the upper end of the tumor. If it is impossible to reach the upper end and the latter is left, no bad results are to be expected in benign growths, and metastases of mixed tumors are usually hematogenous and less to be feared than metastasis in carcinomata. The caudal appendages, true or false, are readily removed. In the case of sacral parasites, any connection between the parasite and the vertebral canal of the autosite should be carefully looked for.

TUMORS OF THE VERTEBRÆ.

Tumors of the spine are rare (1.5 per cent. of all tumors, Schlesinger). Over 90 per cent. are malignant and the great majority are secondary or metastatic growths. Direct extension may occur from gastric and esophageal carcinomata.

Varieties of New-growths and the Features Peculiar to Each.——**Carcinoma** of the spine is more common in women, as the primary focus is generally in the breast or uterus. Occasionally the primary cancer is not discovered, or at least not until after the pain due to the metastatic focus has led to a careful examination. Several vertebræ are usually involved at once, most often in the dorsal and lumbar regions. The tumor is usually in the body of the vertebræ, the cortex of which may remain intact for a considerable period. In some cases the spine suddenly telescopes and becomes shortened or deformed. Cancer can rarely be palpated, as it does not extend beyond the vertebral bodies. Compression of the cord may be due to extradural masses, congestive edema, or bony displacement. The spinal nerves are more subject to compression than the cord, as the intervertebral foramina are especially liable to be encroached upon.

Sarcoma of any kind occurs just as does carcinoma. It develops in the bone or periosteum of the bodies, but may sometimes commence in the arches or spines or extend to them from the bodies. Tumor masses may be felt through the skin in the case of sarcoma, as the growths extend beyond the bone. It is more apt to encroach upon the canal or even penetrate the dura than a carcinoma. Sarcoma softens the bone so that the superincumbent weight, especially in the lumbar region, compresses and flattens the bodies. The "settling" produces agonizing pain. Primary sarcoma is more common in the spine than primary carcinoma; the reverse is true of secondary growths.

Myeloma, a non-malignant tumor resembling red bone-marrow, is always multiple, and causes a softening, rarely a sclerosis, with deformity when it attacks the spine. The cord is compressed by the pressure of the tumor or by the deformity. There are no metastases. Albumose is found in the urine in the majority of cases, in 11 out of 19 cases collected by Thomas.[22] The latter found 11 cases in the literature in which the spine was involved.

Exostoses and **enchondromata** are not uncommon, the latter often ossifying. Cartilaginous exostoses are comparatively common. These and other benign growths, like angiomata, are of interest only when they grow toward the canal and compress the cord or nerves. Echinococcus cysts are rare and hard to diagnose. They may cause spontaneous fracture, and if they burrow posteriorly may rupture in the back.

Symptoms.—We may subdivide the symptoms into those due to the disease in the bone itself, and those due to pressure (1) on the nerve-roots or nerves and (2) on the cord. The process in the bone may cause pain, and this may be spontaneous or only produced by movement or pressure over the spinous process or on either side. The malignant tumors and myelomata usually cause a deformity, generally in the form of a rounded, not an angular, kyphosis. It not infrequently appears suddenly, causing a condition of contusion or pressure on the cord similar to that in compression fractures. In fact, such a fracture or fracture-dislocation may actually occur. In addition, in cases of enchondromata and sarcomata the tumor itself may cause a prominence in the back.

Pressure or infiltration of the nerve-roots or nerves causes the principal symptom of malignant tumors of the spine, an intense neuralgia, usually bilateral. The intervals between the attacks become shorter until the frightful pain is nearly continuous. The neuralgia, like the bone-pain, may be limited to a relatively narrow area, even when the growth is extensive, and is present in about 60 per cent. of cases.

The cord symptoms are the result of pressure and appear later. They are usually bilateral. As already stated, the cord may suddenly become contused or compressed, just as in fracture, when the spine collapses suddenly. Clinically, sarcoma of the spine may bear a close resemblance to acute spondylitis.

Benign tumors produce no symptoms except those due to pressure, and these are similar to those of extradural intraspinal growths.

Diagnosis.—This is often difficult until after the lapse of some time. A primary tumor elsewhere or the history of its removal, even years before, is of great diagnostic importance, and the presence of bone, nerve, and cord symptoms suggests a growth in the spine. However, the primary tumor may not be found clinically, and spinal caries may occur at the same time with a malignant growth elsewhere, and may cause bone and pressure symptoms.

Caries of the spine is far commoner than tumor, and its deformity is usually angular, not of sudden appearance, and is often accompanied by abscess. The pressure symptoms are apt to disappear rapidly in caries, and this recovery from the symptoms excludes malignant growths.

Pain in spinal caries is usually diminished by extension, while that due to tumor is apt to be aggravated by it.

The severity of the pain, its resistance to treatment, and its frequently bilateral distribution help to diagnose the neuralgia of spinal tumor from simple neuralgia and neuritis.

The diagnosis from intraspinal growths may be very difficult unless a tumor is to be felt externally or there are similar growths elsewhere, as in some sarcomata and exostoses, or a deformity of the spine occurs. The sequence of symptoms may here be of some service, for in tumors of the vertebræ the bone symptoms appear first, and in intraspinal tumors they occur last or not at all. Not infrequently, however, the first symptoms noticed in a tumor of the vertebræ are the root symptoms, the bone symptoms being absent or delayed. In addition, a most important diagnostic aid is the *x*-ray, which shows not only the presence but the extent and position of the growth in very many cases.

The variety of the growth can be determined in secondary tumors, in exostoses, and usually in myelomata. In other cases sarcoma would be suspected as the commonest growth, also where the tumor involves the tissues about the spine. An ecchinococcus cyst can be diagnosed only by examining its contents.

The **prognosis** is bad in malignant tumors. Several cases of primary sarcoma have been operated upon with good results, but late reports are wanting bearing on the question of recurrence. The average duration of life is nine and a half months with carcinoma and eleven months with sarcoma (Schlesinger). The benign growths are only serious if they grow within the canal so as to produce symptoms of pressure on the cord. Even then exostoses may cease to grow after reaching a certain size. Echinococcus cysts may rupture spontaneously and a cure result.

Treatment.—In carcinoma operative treatment is useless, so is it in any malignant growth of the spine in the presence of such a growth, primary or secondary, in other organs. In primary sarcoma operations have been performed and reported by Israel,[23] Kümmel[24] (2 cases), Sick,[25] Davies Colley,[26] and others, with the relief of symptoms. The ultimate results are not given. In one of Kümmel's cases the sarcoma involved mainly the spinous processes. Both Israel and Kümmel opened the pleura without bad result and the latter resected several ribs. Sick only partly removed the tumor by curettage and treated the patient by the injection of large doses of arsenic for a long time. The *x*-ray now shows complete cure. In the case of myeloma reported by Thomas[22] the tumor was removed by Munro and the case treated by bone-marrow and the injections of erysipelas toxins with good functional result.

In inoperable malignant tumors of the spine it would seem wise to use Coley's fluid systematically and at the same time to treat the pain. Sudden collapse of the spine may be avoided by immobilization with plaster-of-Paris, but without extension, for this is not well borne.

In benign growths removal is indicated if they encroach upon the canal or compress any of the nerves at their exit. Exostoses and excessive callus formations are the most favorable for operation, but these conditions may occasionally reappear after removal. Operations on echinococcus cysts give a favorable outlook. As it is not always possible to make the differential diagnosis between an operable and an inoperable tumor, an exploratory incision is indicated to settle the question. If there is any doubt as to the diagnosis between a syphilitic spondylitis, etc., and a spinal tumor, potassium iodid may be used to aid the diagnosis unless pressure on the cord is present, in which case an exploratory operation is preferable.

INTRASPINAL TUMORS.

Intraspinal tumors, often loosely called tumors of the spinal cord, comprise extradural, intradural, and intramedullary growths. With the exception of cysts and lipomata, the first two grow from the meninges or the inner surface of the canal; the last is a growth within the cord, usually a glioma, sarcoma, or tubercle, and inoperable. Hence the latter is of little surgical interest except in diagnosis.

Fig. 558.—Metastatic Tumor of Spine (Hahn)

Intraspinal tumors are not common, but Krauss[27] has collected 96 cases operated on, up to the early part of 1906, since the year 1887, when the first case was successfully diagnosed and operated upon by Gowers and Horsley.[28] This opened a new field of surgery. The above series of cases exclude cases of Pott's disease with secondary tumor formation (such as have been reported by MacEwen), syringomyelia, and the eight cases which antedate the Horsley-Gowers case and were not, strictly speaking, intraspinal tumors.[29]

Varieties.—The most common extramedullary tumor is sarcoma; next in order fibroma, endothelioma, myxoma, lipoma. The latter is generally congenital. Psammoma, enchondroma, neurofibroma, and some other varieties also occur rarely. I have seen one case of an intraspinal neurofibroma in connection with general neurofibromatosis, and a few other such cases have been reported. Echinococcus and cysticercus cyst are the only parasitic cysts, the latter variety being the more common. Non-parasitic cysts and localized collections of clear fluid [35, 35a] in the subarachnoid space, which produce more or less paralysis from pressure, also occur. Intraspinal dermoid cysts are rare, but a few cases have been operated on and reported. Tuberculous lesions are among the commonest causes of pressure on the cord. They occur in the form of tubercles (single or multiple), tuberculous abscess, and cicatricial masses which are left by a healed tuberculous focus. Gummata are not uncommon—28 in 400 (Schlesinger). They usually originate in the pia and are apt to infiltrate the membranes and the cord and to destroy the latter.

The malignant neoplasms are much more common than the benign, in the ratio of 10 to 1. But it has been observed [30, 31] that although the microscopic diagnosis is often sarcoma, the clinical history, both as to the time such tumors have existed before operation and the absence of recurrence after operation, shows them to be relatively non-malignant.

Sarcomata of the spinal meninges are relatively benign and the pia forms a barrier to the involvement of the cord. Many of the intraspinal sarcomata belong to the comparatively benign endothelioma type. All intraspinal tumors, though usually small, unless removed ultimately cause death from the effects of pressure on the cord.

The intradural are more common than the extradural meningeal growths, nearly in the ratio of 2 to 1. The intradural growths are frequently encapsulated, and in most cases they are separable from the cord internally and the dura externally without serious damage to either. They are not infrequently covered by one or several delicate layers derived from the arachnoid, and cystic cavities around or within them are quite common. The sarcomata and fibromata may start from or be inseparably connected with one or more nerve-roots.

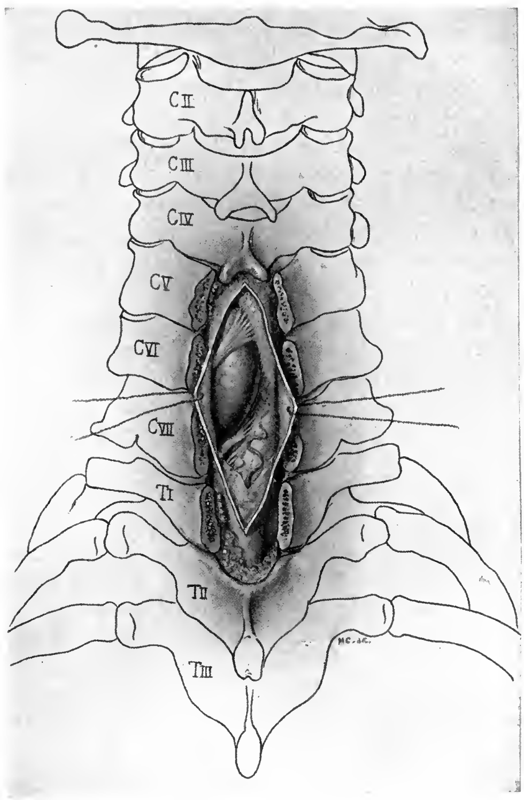

Fig. 559.—Intradural Tumor of the Cervical Meninges.

Semischematic view. From a sketch at the time of operation of the position of the growth in relation to the inclosing vertebræ (Harvey Cushing).

As to **situation** the tumors are generally on the posterior or lateral aspect of the cord, seldom anteriorly. The larger number are in the thoracic region, next in the cervical region, but in proportion to the length of cord involved the cervical tumors operated on have been about as frequent as the dorsal.

Etiology.—Little is known of this. The growth is not infrequently attributed to a fall, which is soon followed by symptoms. Tuberculosis and syphilis may be causes. Intraspinal tumors occur more often in men between the ages of twenty and fifty, but no age is peculiarly liable, except that tuberculosis generally occurs in young subjects.

The term intraspinal tumor is used in its broad sense to include all those allied conditions, like the granulomata (tuberculous and syphilitic), cysts, and the products of inflammation, which produce gradual pressure symptoms.

Symptoms.—These depend upon pressure or the degeneration resulting from it, and are divided into two groups, the nerve-root symptoms and the cord symptoms. They, of course, vary in each individual case, depending upon the position of the tumor and the segment affected, thus giving us the data for the diagnosis as to the situation of the tumor.

Root Symptoms.—These are due to pressure on the nerve-roots, commonly the posterior roots, on account of the position of the tumor, and are the first to appear in extramedullary growths. They consist of pain and often of paresthesia and hyperesthesia.

The pain is at first vaguely neuralgic, but soon becomes definitely localized, very persistent, agonizing, boring or burning. Usually unilateral at the outset, it later becomes bilateral, as a rule, depending upon the position of the tumor. This extension is important diagnostically. The pain does not correspond to the course of the nerves, but to the distribution, more or less horizontal on the trunk, of the sensory area of the root first affected. It is often increased by jars and movements of the body. There are no tender points, as in neuralgia. Muscular spasms often attend the pain, especially in intradural growths. The pain often leads to a mistaken diagnosis of neuralgia, rheumatism, angina, lumbago, or sciatica. If in time the sensory roots first affected become degenerated, paresthesia, especially numbness, and diminished sensation, and then anesthesia take the place of pain, which usually, however, appears in neighboring roots from the extension of the growth. The painful areas are apt to be hyperesthetic. Paresthesia, such as numbness, prickling, or burning, is common in the same areas, but may not occur for some years after the onset of the pain. It is most commonly present in the feet. Herpes zoster often accompanies the nerve-root pain. An extramedullary as well as an intramedullary tumor may occur without root symptoms, at least for a long time.

Cord Symptoms.—These are characteristic and are due to the compression or destruction of the segment or segments on which the tumor lies. They may not occur for some years after the first root symptoms —nine years in one of my own cases—or they may follow the latter more closely. They vary with the segment involved, and consist of motor and sensory paralysis and alteration of the reflexes.

The *direct spinal symptoms* are due to the compression or destruction of the spinal centers in the segments involved. There is paralysis with atrophy and reaction of degeneration of the muscles whose centers are compressed. The tendon reflexes centering in these segments are lost. Anesthesia may occur with analgesia and thermic anesthesia, or the latter may be present without the former. Herpes zoster and other trophic disturbances may occur.

The *indirect spinal symptoms*, from compression of the long tracts of the cord, consist of spastic paralysis with exaggeration of the tendon reflexes in the legs, anesthesia, imperfect control of the bladder and the rectum, and a tendency to decubitus. At the outset weakness with rigidity appears and gradually increases to paralysis. The paralysis at first is usually on one side, the side of the tumor, and may later extend to the opposite side. The extension of the motor paralysis is usually from above downward. It remains most pronounced on the side first involved.

The anesthesia first occurs on the opposite side, except the loss of muscle-sense, which is on the same side; later the anesthesia may extend to the same side. Occasionally the symptoms are those of a Brown-Séquard paralysis. The diminution of sensation is variable in degree and all sensations are usually involved, but not to the same extent. This diminution of sensation usually begins and is most marked below and extends upward. Dissociated anesthesia, characteristic of syringomyelia and intramedullary hemorrhage or growths, may occur in extramedullary growths, as I have observed in two cases.[31] A girdle sensation is often present near the level of the tumor. Above the hypesthetic area there may be a narrow zone or irregular patches of hyperesthesia or of uncertain or diminished sensation, above which sensation is normal.

Local tenderness or sensitiveness of the spine over the segments or posterior roots involved occurs only when the lesion is posterior, and is generally the only symptom referable to the spine in intraspinal tumors. A sudden onset or increase of symptoms may occasionally occur, and is to be attributed to hemorrhage into or edema of the tumor or of the cord.

If the tumor involves the first dorsal segment,[32] or those above, the ciliospinal center may be affected, resulting in a narrowing of the pupil on the same side, and sometimes profuse sweating of that side of the face and neck. In tumors of the lumbar region the paralysis is atrophic. In tumors of the cauda equina the sensory symptoms predominate and are wide-spread. At first there is pain on movement, later persistent, then anesthesia. Muscular weakness with atrophy develops slowly. The tendon reflexes, at first exaggerated, are soon diminished and finally lost. In lesions of the conus medullaris the symptoms develop more rapidly, the sensory disturbances may be dissociated, tactile sensation being often preserved, and pain is not a marked feature.

Prognosis.—A fatal result from the effects of cystitis or decubitus is only a matter of time. Starr gives the average duration as sixteen months, but in my own cases the symptoms had existed from ten to two years. The average duration of symptoms before operation in Harte's series was two and one-fourth years. Gummata may improve under antisyphilitic treatment and tuberculous processes may subside. Henschen[33] has described a case, apparently of intraspinal pseudoneuroma, which recovered spontaneously. The prognosis is more serious, the higher the situation of the tumor.

Diagnosis.—The diagnosis should be made from the persistence of pain and the sequence and distribution of the symptoms. The persistence and distribution of the nerve-root symptoms should lead one to suspect an intraspinal tumor. As soon as the first cord symptoms are associated with them a positive diagnosis should be made before pressure on the cord has caused degeneration of its tracts, for recovery from the symptoms dependent upon this is not to be expected.

To be operable the tumor should be single, or if multiple all at the same point. In scattered multiple growths the pain occurs in several distinct regions and the type of paralysis is mixed, being more atrophic and less spastic than otherwise. In Schlesinger's table multiple growths occurred in 31.75 per cent. of cases. After making the diagnosis of a probable single and operable tumor we must differentiate it from other conditions whose sypmtoms resemble it in certain respects (differential diagnosis), and then determine its position, whether intradural or extradural, its nature, whether benign or malignant (if possible), and its localization (niveau-diagnosis).

The differential diagnosis in the period of root symptoms is difficult, as the symptoms of pain and paresthesia are so common in affections of the nervous system. The distribution of the pain due to a tumor in root zones, its violence and persistence, its increase on motion, and the absence of tender points are the chief features in differentiating it. A bilateral sciatica is very suggestive of tumor. In tuberculous spinal caries the symptoms are seldom unilateral, the progress is more acute, arrest of progress or improvement may occur, fever is present, as a rule, and peptonuria often, and there may be evidence of tuberculosis elsewhere. The spine also is more tender and stiff, and finally when kyphosis occurs the diagnosis is evident.

In the period of cord symptoms, characterized by motor and sensory paralysis and disturbance of tendon reflexes, we must diagnose a suspected tumor by the character and sequence of the symptoms. This is almost always possible, and generally easy, but several cases of syringomyelia have been operated on for a spinal tumor.

The **position** of the tumor with reference to the meninges can often be fairly accurately surmised from the following considerations. Extradural tumors are more likely to be malignant and are more rapid in growth and course of symptoms than intradural. From their tendency to extend longitudinally, the former are more likely to involve a number of nerve-roots before producing cord symptoms. Both the root and cord symptoms are more apt to be bilateral or incompletely unilateral in extradural tumors, and the symptoms due to pressure on the cord may long remain absent, while the bone is more apt to be involved early. In the intramedullary growths root symptoms may appear late or not at all, and there is often dissociation in the disturbances of sensation. There is no absolute clinical distinction between intramedullary and extramedullary tumors, and it is by no means always possible to distinguish between an intradural and an extradural tumor.

The **variety of tumor** can only rarely be diagnosed. In children, especially if there is a spina bifida, the tumor is probably a lipoma. A definite history of syphilis usually indicates a gumma, though not necessarily so. Sarcoma is by far the commonest tumor, but it does not necessarily imply a rapidly growing tumor. A malignant type of sarcoma usually grows rapidly. Extradural tumors are more likely to be malignant. The duration of symptoms throws little or no light on the variety of the tumor.[30] A tumor elsewhere only helps us in metastatic growths.

The **niveau-diagnosis,** or the localization of the exact level of the tumor, is the most important preliminary to a successful operation.

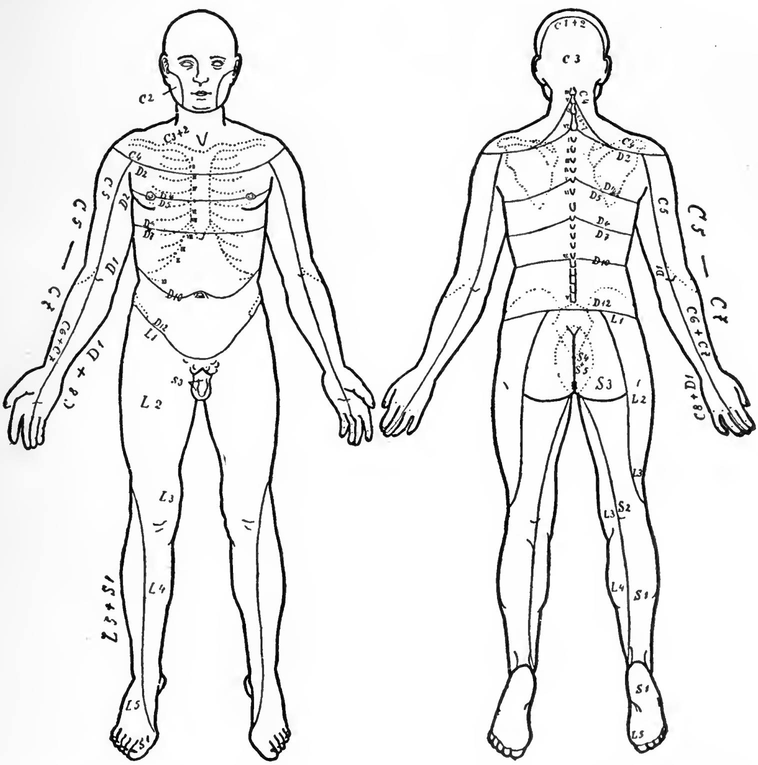

Fig. 560.—Diagram Showing Sensory Supply of the Spinal Cord Segments (Seiffer).

Here particularly the surgeon should rely upon the skilled neurologist. In six consecutive patients I have found the tumor at the point indicated by the neurologist. The level of the anesthesia and the pain are the most reliable indications. The symptoms due to a lesion of a segment or of its nerve-roots, at a lower level, are the same. The sensory segments or root zones have been fairly accurately determined by the work of several investigators and are shown in Fig. 560.

Formerly the tumors localized by the anesthesia were often found higher up than supposed, as in Horsley's first case. This is explained by the investigations of Sherrington, who found that the cutaneous area belonging to each spinal segment so overlaps those of the neighboring segments, and that the cutaneous branches of the posterior primary division of the spinal nerves anastomose so freely with each other, that in no instance does a single segment or root wholly supply a given area of skin (or a single muscle as well), but at least three (and Bruns says five) of them participate. Hence the upper border of anesthesia points to a lesion of the next higher, or perhaps the second higher, segment than that represented by the level of anesthesia. As the zone or area supplied by the upper of the affected segments is also supplied by the segment, or perhaps the two segments, above it, this is not anesthetic, but may be the seat of diminished or uncertain sensations or hyperesthesia. The lowest level of the intraspinal lesion corresponds to the highest level of the sensory disturbance. Several reports[32, 34] of operations or necropsies show that the tumor, or its upper end, was in the segment represented in the highest zone of disturbed sensation, *i. e.*, the zone where diminished passed into normal sensation. Furthermore, it is not definitely known what distance, if any, the afferent and efferent tracts run in the cord before they reach their real centers. The spinal segments, and hence a tumor compressing any of them, are at a higher level than the corresponding segment zones on the skin of the back, on account of the course of the nerve-roots from their origin in the cord to their foramina of exit from the canal and the downward passage of the posterior nerves to reach their areas of distribution. Thus, according to Starr, in the dorsal region the segment of the cord is 10 cm. (4 inches) higher than the anesthesia. The relation between the segments of the cord and the bodies and spines of the vertebræ is shown in Fig. 561. Chipault has reduced the relation of the segments to the spinous processes to the following rule, which is fairly accurate: In the cervical region add one to the number of the vertebra to give the segment opposite its spine; in the upper dorsal region, add two; from the sixth to the eleventh dorsal vertebra, add three. The lower part of the eleventh dorsal spine and the space below it are opposite the lower three lumbar segments. The twelfth dorsal spine and the space below are opposite the sacral segments. Some individual variation in the segmental distribution as well as in the relation of the segments to the spines of the vertebræ may occur, but the figures showing both of these represent average conditions fairly accurately.

A point of greatest tenderness on pressure over the vertebral spines or to one side is often present when the lesion is situated posteriorly. Among 85 cases Krauss found it present in 31 cases, absent in 15, and not mentioned in 33. I have observed it in 3 out of 7 cases. When present, it is thought by Krauss to be a certain guide to the segment or posterior root involved, provided, of course, that caries can be excluded; its absence means nothing. Starr places little value upon it.

If the root pain is carefully observed, it may lead to the niveau-diagnosis of the commencement of the lesion, but as the pressure on the root may occur at any point of its course within the canal, the level of the lesion cannot be so accurately determined as by the anesthesia due to pressure on the cord. The muscular paralysis is of much less

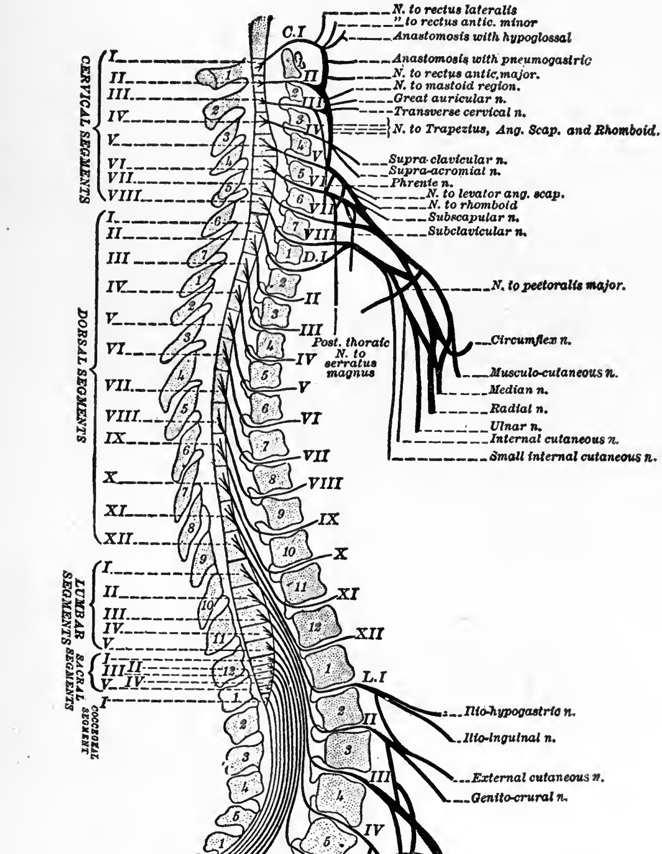

FIG. 561.—THE RELATIONS OF THE SEGMENTS OF THE SPINAL CORD AND THEIR NERVE-ROOTS TO THE BODIES AND SPINES OF THE VERTEBRÆ (Déjérine and Thomas, modified by Starr).

value in the niveau-diagnosis, but by reference to the table of the motor supply of the various segments (page 865) we may infer the segment involved with some accuracy.

In particular sections of the cord special symptoms may help us in the localization of the tumor (see Symptoms). It is not difficult to determine the side of the cord on which the tumor lies if the early symptoms are carefully noted. I have operated on a case in which a large posterior tumor gave no posterior root pain for some years after the initial symptoms. Among 100 cases Starr found 75 operable from a pathologic point of view, and in 54 of these an accurate diagnosis was possible.

Treatment.—No treatment but operative should be considered unless there is a distinct history of syphilis, when active anti-syphilitic measures may be adopted. But as these may only partially relieve the symptoms and not entirely remove the tumor, operation is still indicated. When there is only a suspicion of syphilis, no time should be lost before operation in anti-syphilitic treatment; for the continued pressure may cause degeneration of some of the fibers or cells of the cord, and recovery from the resulting paralysis never occurs. Hence the rule should be to operate as soon as a diagnosis of the presence and position of the tumor can be made. Before operation morphin may be necessary for the pain. Formerly the tumor has often been found above the position selected for operation, but there is little excuse for it now (page 841). However, owing to the possibility of individual variation and to allow for a slight margin of error in the localization, as well as to give sufficient room for the operative technic, at least three laminæ should be exposed and removed.

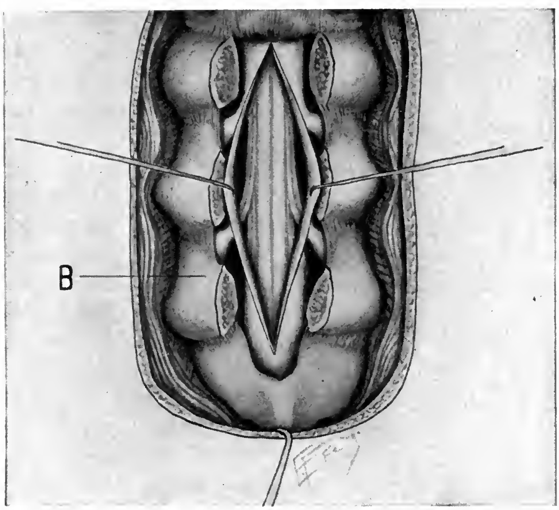

Fig. 562.—Osteoplastic Resection of the Spinal Column. B, Spinal canal exposed, showing the membranes incised and retracted, together with the nerves and their course to the spinal foramina (Bickham).

The patient, under ether anesthesia, is placed in a modified Sims position, as prone as is consistent with easy respiration, and on the left side, as this is more convenient for the operator, whether the tumor is on the right or left side. The region to be exposed should be flexed as much as possible to facilitate the laminectomy, and raised by a pillow or by tilting the table to diminish the escape of cerebrospinal fluid when the dura is opened. The exact site of the spines is sometimes difficult to determine, so that they should be counted both from above and below, unless near the upper end. Careful preparation of the operative area should be made beforehand and on the table, and if a bed-sore exists on the back it should be treated thoroughly with pure carbolic acid followed by alcohol.

Laminectomy, the first step in the technic of the operation for intraspinal tumors, may be described here once for all, as the technic is essentially the same for whatever condition it is done. The simplest technic is the best. The osteoplastic methods, such as Urban's, Abbe's, or Bickham's, should accordingly be discarded. They offer no advantage, take a longer time, Sonnenberg attributed a fatal result from meningitis to the use of Urban's method, and the laminæ add little, if anything, to the strength of the spine and do not bear any of the weight carried by it. A median incision over three to five spines, with its center over the supposed position of the tumor, is carried down to the tips of the spinous processes and to both sides, keeping close to bone. A transverse division of the aponeurosis at the ends of the incision, to allow easier retraction of the edges and exposure of the spine, is not needful, but may be used if desired. Then with the elevator the muscles and periosteum are stripped away from the sides of the spines and the back of the laminæ to their outer limit. As there is apt to be more or less bleeding, mostly venous, at this stage, the two sides should be attacked alternately, keeping the opposite side packed with gauze wrung out of very hot normal salt solution. In this way little or no trouble is experienced from hemorrhage and almost no forceps or ligatures are required. After cutting the interspinous and supraspinous ligaments on either side of the spines the latter are removed close to their bases with a strong pair of bone cutters bent on the flat. With a rongeur, bent on the edge and having the under jaw flattened, the lamina beneath which the tumor is located is removed piecemeal, care being taken not to injure the dura or press upon the cord. This is not difficult after we have once made a beginning and entered the canal, and is still easier with the other laminæ to be removed. This will be found to be as rapid and easy as any method, but several modifications in technics have been employed by various operators. Using the rongeur to remove the laminæ, I have had no trouble with hemorrhage from the bone, any slight oozing being soon

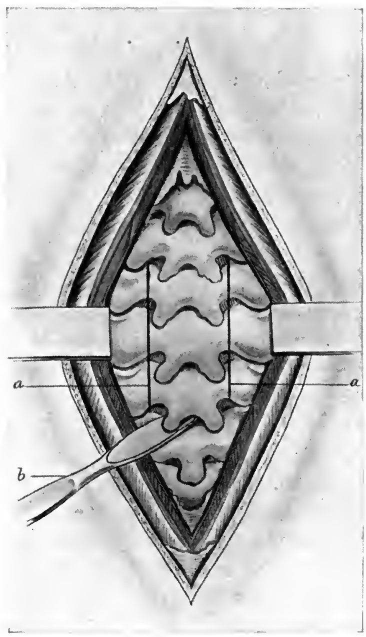

FIG. 563.—LAMINECTOMY.

a, a, Saw cuts through the laminæ, just within their junction with the articular process; *b,* knife dividing the ligamenta subflava (Bickham).

checked by pressure with gauze or by Horsley's wax. The ligamenta subflava adhere to the dura, but are readily peeled off.

If the tumor is extradural and posterior, it is now exposed and may be removed. The compressing masses of cicatricial tissue are extradural. The extradural tumors, and especially the cysts, often extend a considerable distance longitudinally, requiring the removal of several laminæ. Starr advises opening the dura even in extradural tumors, as a secondary growth may be found within, but it is not always necessary. Before opening the dura, make sure that no extradural cause of pressure exists by exploration above and below with Horsley's dural separator.

The question of operation in one or two sittings now has to be answered. The decision depends on the previous strength and the present condition of the patient, whether much blood has been lost, what the blood-pressure is, and how long the operation has already lasted. I have advised operating in two stages, with enough of an interval to allow recovery from the shock of the first operation, if there is any question as to the patient's ability to survive the complete operation. I was forced to use it in one case, which resulted successfully, and am of opinion that a fatal result in another case might possibly have been averted by operating in two stages. This method is recommended by Brodnitz[36] as a routine practice. If employed in a case of intradural tumor, the question arises whether to open the dura in the first stage. If the condition of the patient justifies it, I would advise opening the dura to see if a tumor is actually present and learn the direction in which it extends to determine whether and what additional laminæ require removal at the next operation. If it is decided to operate in two stages, the dura, if opened, should be sutured, the wound lightly packed with gauze and brought together by two or three temporary sutures. If the patient's condition, etc., justifies it, there is a distinct advantage in completing the operation in one stage.

If all the dura exposed does not pulsate, increase of intradural tension, a tumor, adhesions, or some other cause of loss of continuity of the subdural space is indicated. An intradural tumor, even if situated posteriorly, is not usually demonstrable until the dura is opened; nevertheless the dura should be palpated before it is opened. If it feels more tense and elastic than normal, a tumor or an increase of cerebrospinal fluid probably exists. It is often wise to open the dura at the point where the tumor is localized as soon as two laminæ have been removed to see the position and extent of the growth and then to remove any additional laminæ necessary.

If the tumor is intradural, any epidural fat lying posteriorly is removed or divided in the median line, and the dura is opened by a sharp-pointed knife and slit up with scissors in the posterior median line. The two margins of the dura are held apart by retractors, forceps, or silk sutures. The flow of cerebrospinal fluid may possibly be annoying at this stage, but if the part operated on is raised as much as possible above the rest of the spine and the head, no further expedients are necessary to check the flow, for it quickly ceases. Thus, gauze gently packed between the dura and cord posteriorly,[31] and a circular extradural constriction by a temporary silk or elastic ligature,[34] though effective, are unnecessary.

The tumor may now be seen, or it may be so covered with many layers of arachnoid, which is often edematous, that it is quite obscured. Only after the division of these overlying layers is the tumor itself brought to view, perhaps surrounded by a cyst. Access to the tumor may necessitate the division of one or more posterior nerve-roots, which should be subsequently sutured. As a rule, the tumor, which is commonly encapsulated, can be shelled out with only trifling hemorrhage by blunt dissection, by a small scoop or elevator, and by dissecting forceps, occasionally dividing any strands of connecting tissue with the knife, after ligating any which contain blood-vessels with fine catgut. Cysts are readily evacuated and the cyst wall removed. The tumor should first be separated from the cord, and this may require the division of a thin layer of tissue connecting the coverings of both. Occasionally it has grown from or is so incorporated with one or more nerve-roots as to require their resection.

In some cases it may be wise to remove longitudinal wedge-shaped pieces from the tumor to reduce its bulk, so as to avoid any additional compression of the cord in enucleating it. If for any reason the cord is to be incised, the line of section should be exactly longitudinal. Irrigation with warm normal saline solution from time to time is useful to clear the field of operation. The sponging should be gently and carefully done. If necessary, additional laminæ must be removed to expose the ends of the tumor.

If no tumor is found, do not hesitate to remove, if necessary, the four or five laminæ higher up, as there is less danger in a mistaken diagnosis than in failing to find the tumor. The canal should be opened to the uppermost limits indicated by the slightest changes in sensation. If the patient is unable to stand this procedure it has been successfully done after an interval of a couple of days.[30] If the tumor cannot be removed, the posterior nerve-roots at and above the level of the tumor should be divided. This, together with the relief of pressure by the laminectomy, affords great relief.

The dura should then be sutured with fine catgut with a round or surgeon's needle, and should not be drained, as a rule, though a few[30] advise free drainage of cerebrospinal fluid. The muscles are brought together by interrupted sutures of chromic catgut to obliterate any cavity. The aponeurosis is sutured with chromic catgut, leaving a small cigarette drain, down to the dura, at the lower end for forty-eight hours. The skin should be sutured with silk reinforced with silkworm-gut. The latter is left in ten to fourteen days to avoid separation of the skin wound after primary union and removal of the silk sutures, which I have seen in two cases.

The After-treatment.—The patient should be placed on an air-bed. No special support for the spine after operation is necessary. Morphin will be required, often for several days, for the pain in the back and in the limbs, especially on motion, or for painful cramps. The wound must be carefully protected from soiling by involuntary passages from the rectum and bladder, or, if a bed-sore already exists, from its discharge. Great care must be taken to keep the patient's back clean and dry to prevent bed-sores. I have never found it necessary to keep the patients prone, but have them lie on the back and turned on the side for a change as soon as this position is not painful.

In some cases, especially in extradural growths and cysts, the relief of pressure is shown almost at once in the relief of symptoms. In other cases the necessary handling and the resulting edema cause an increase of the paralysis at first, but affect sensation but little. The root pain is nearly always relieved to a marked degree. Improvement may not set in for a week or two, and then proceed slowly but steadily, first the sensory and then the motor paralysis improving.

If there is leakage of cerebrospinal fluid, this may be diminished and finally stopped by pressure. This leakage, even to a considerable amount for two weeks or more, may do no harm, though it has seemed quite possible that it accounted for the partly irrational condition sometimes present. Brodnitz[36] suggested that it caused the rise of temperature in two aseptic cases. According to Henle, the flow of cerebrospinal fluid has repeatedly been followed by a fatal termination even without infection. It is always annoying and may add to the risk of infection.

The period of rest in bed varies with the special conditions present in each case from two to four, six, and even ten weeks. As a rule, patients should be kept in bed for at least three weeks.

Results.—Mortality. Among the 96 cases collected by Krauss, 10.4 per cent. died in the first twenty-four hours, 20.8 per cent. within the first week, and 39.5 per cent. within three months; 53 per cent. recovered or were improved (42 per cent. cured and 10 per cent. improved). These figures agree closely with those obtained by Harte.[30] Among the recently reported cases the mortality is lower. Among 7 cases operated on by myself the mortality has been 14.3 per cent. McCosh[37] has stated that the mortality of laminectomy should not be over 10 per cent. If, in cases requiring it, the operation is done in two stages, the mortality certainly should not exceed 15 or 20 per cent. It is quite remarkable how many cases called sarcoma pathologically have recovered and remained well, *i. e.*, 13 recovered and 6 improved among 41 operated on in Krauss' table.

The principal causes of death are shock and meningitis. The former can be reduced to a minimum by guarding against hemorrhage (page 846) and operating in two stages when the operation is not well borne. The shock is less than in operations on the brain and, as a rule, is not serious. Meningitis is due to infection and should be avoided by careful technic. It is most likely to occur when a bed-sore is present.

The immediate result depends upon the amount and duration of the pressure and the amount of traumatism required to remove the tumor. When the pressure has been neither long continued nor severe, and little or no damage is done to the cord, as in extradural tumors, the improvement is immediate and rapid. Some pain from disturbance of the posterior nerve-roots may be present for a time. In intradural tumors, where more traumatism is likely to be inflicted on the cord in spite of the greatest care, the paralysis (especially the motor paralysis) is often temporarily increased after the operation, and if the pressure has been long continued and severe, the recovery is slow. Those parts improve first and most rapidly which are last and least paralyzed and vice versâ. There is no hope of recovery when the nerve-fibers or cells have become degenerated from pressure. If the operation is done early, recovery may be practically perfect or only a slight degree of spastic paraplegia or monoplegia may remain. Improvement continues for a year or two and sometimes longer.[38]

Starr says that intraspinal tumors usually recur, but the relative frequency of recurrence is less than with similar tumors elsewhere, for in nearly or quite half of the cases[30] removal of intraspinal sarcomata insures against recurrence. In tuberculous intraspinal lesions, except in the case of the thickenings due to a healed process, the results are not so good as those from orthopedic and general treatment, for there is danger of setting up a tuberculous meningitis, a tendency to recurrence, and the lesion is more often in the cord than in the membranes and not operable. A successful operation stops the progress of the tumor and saves life, for the prognosis is hopeless without operation.

The foregoing is a very strong argument in favor of early operation, for in most of the reported cases the results would have been better if the operation had been done earlier. Even in the inoperable medullary growths great and prolonged relief may be given by relieving pressure by a laminectomy.[38] No successful case of removal of an intramedullary growth has yet been reported, and in general they are inoperable except for palliative laminectomy with or without division of the posterior nerve-roots. The spine itself may be somewhat stiff after operation in some cases; in others entirely normal.

OPERATIONS ON THE POSTERIOR NERVE-ROOTS FOR INTRACTABLE NEURALGIA.

The field of this operation is a relatively small one. The indications are cases of severe neuralgic pain, usually due to an ascending neuritis and in the upper extremity. In spite of medical treatment of all kinds, stretching and resection of the nerve, and even amputation of the limb, the condition goes from bad to worse, and the patient resorts to morphin with little benefit. The value of the operation consists of saving the motor roots and their function when this is important. The operation is also indicated and is the only means of relief in neuralgia whose distribution shows it to be a neuralgia of the roots. The posterior nerve-roots are also to be divided, as already stated, in cases of spinal cord tumor when radical operation is not applicable. At the first, Dana pointed out one advantage of the operation, namely, that if a tumor or other lesion is found as the cause of the neuralgia, it may be dealt with instead of dividing the roots.

As already stated (page 842), to anesthetize any area of skin the nerve-roots on either side or even two above[39] those in whose sensory areas the pain is situated must also be divided.

The **operation** was first suggested by Dana and carried out by Abbe in 1888. The nerve-roots may be divided extradurally, as in Abbe's first operation, but here the anterior root would be liable to be included, which is objectionable unless the motor root is of slight importance or the limb has been amputated or athetoid movements are present, as in Abbe's third case. Also, unless great care is taken to destroy or remove the root ganglion, the sensory fibers would surely regenerate if divided external to the ganglion. When the root is cut between the ganglion and the cord, there is degeneration of the fibers from the point of section to the cord and up the posterior columns of the latter. These intramedullary fibers do not regenerate. Hence the intradural section is preferable and the resection of half or quarter of an inch of the nerve is ample for permanent cure.

The *technic* consists, first, in a laminectomy as already described (page 845). Four or five laminæ should be removed and the dura opened for the entire length exposed. The nerve-roots may be identified by the point of their exit from the canal, but in case of doubt the corresponding anterior root may be stimulated by a weak faradic current with sterile electrodes and the contraction of the muscles noted. Only one root need be identified in this way; the others may be counted from this. The roots are held up on a blunt hook and divided close to the cord and just where they enter their dural sheath. In the cervical enlargement from a quarter to half an inch of the roots may be excised, and increasing lengths of the lower roots, owing to their longer intradural course. The suggestion of Keen[40] to break up the root ganglion is unnecessary, and it would be difficult to break it up without injury to the anterior root. According to Chipault, the operation for neuralgia associated with muscular spasm is resection of the motor roots. There is no contra-indication to the resection of the third, fourth, or fifth cervical posterior roots, as the phrenic nerve is derived entirely from the anterior roots.

Munro[35] prefers to operate in two stages, on account of his experience with hemorrhage in two cases. Chipault also recommends it, but it is not often necessary and renders asepsis more difficult.

Results.—None of the seven cases collected by Abbe proved fatal as the result of the operation. The resection of the nerve-roots apparently adds little to the shock and danger of the laminectomy. The functional results are encouraging but not wholly satisfactory. In two of Abbe's cases there was great relief, and morphin could be given up. The "pain habit" seems to be so strong in these cases that they still complain of pain at times. Where recovery is not complete we may fairly presume that too few roots were resected. The operation has been one of last resort after neurectasy, neurectomy, and amputation had been tried and failed, and the patient had acquired the morphin as well as the pain habit. If, therefore, the hysterical element be eliminated, it would seem wiser to resort to this operation earlier in any proper case, as no harm would result and an earlier operation would promise better results.

INJURIES OF THE SPINE.

Sprains and Contusions of the Spine.—(A) **Without Involvement of the Cord.**—According to Wagner and Stolper, only 0.71 per cent. of all injuries involve the spinal column, and in one-third of these the cord escapes damage. The many joints of the spine with their numerous ligaments, as well as the ligaments between the laminæ and spinous processes, and the surrounding muscles help to explain the strength of the spinal column and its resistance to injury. But they also indicate the many opportunities for *sprains* of the spinal ligaments. The latter are due to the gradual strain of carrying too heavy loads or to the sudden strain of lifting too heavy weights or of heavy objects falling on the back. Excessive movements of any kind, flexion, extension, lateral flexion, and rotation, such as produce fractures or dislocations if more severe, may produce a "sprain of the back," which is the first stage of a dislocation or fracture of the spine. It should be remembered that sprains, *i. e.*, partial lacerations, of the muscles are also included in the term "sprain of the back." But if these occur apart from sprain of the spine, the pain and tenderness are unilateral or bilateral and not median, and marked local swelling is more likely to be present.

The *symptoms* vary with the degree of the injury, and consist of severe pain on movement and local tenderness. To avoid the pain on movement the back is held very stiff and rigid. A moderate degree of shock may be present at first. There may be slight or considerable swelling and sometimes ecchymosis, which is late in appearing. Owing to the time required for recovery in some of these cases the patients may become depressed and irritable.

Treatment.—Rest in the normal position and avoidance of further strain are all that are required in mild cases. In addition, in the more severe cases stimulants and heat are indicated for the initial shock and hot or cold applications or anodynes internally for the pain. Fixation and support of the back are to be provided by strapping the posterior two-thirds of the trunk or by a plaster jacket. After the local tenderness has subsided, systematic massage should be continued for some weeks or months.

Contusions of the back and spine are often associated with sprains and present much the same features except that the swelling is likely to be more marked and perhaps in the form of a hematoma. As the ligaments are not sprained, the recovery is not so prolonged and the back requires no support.

(B) **Injuries with Involvement of the Cord, and without Fracture or Dislocation of the Vertebræ.**—These consist of more severe contusions or sprains and over-stretching of the cord, or distortion. The violence necessary to injure the cord without fracture or dislocation of the vertebræ is usually very great, for no other organ is so well protected against injury. In exceptional cases a severe lesion of the cord has resulted from a slight injury.

Painter and Osgood[41] collected eighteen cases of rupture of the spinal ligaments, many of them, at least, without dislocation or fracture. The force which produced these injuries was generally a hyperflexion of the spine of a degree less than would be likely to produce fracture. In several of the cases a kyphosis was noticed at the site of the injury which was easily righted by position. When kyphosis was present, there were symptoms of slight pressure on the cord. These soon disappeared when the position of the spine was rectified, and hence were thought to be due to acute bending of the spine. Prolonged rest in a position which favored the repair of the torn ligaments and the support of a plaster or leather corset are required in the *treatment* of such cases. At least some of them would be classed by many as incomplete or isolated fractures or diastasis combined with rupture of ligaments. It is very difficult and, when there is much swelling, oftentimes impossible to diagnose between a severe sprain or contusion of the spine and a slight fracture. The *x*-ray may enable us to make the diagnosis in doubtful cases.

One of the lesions which produces the symptoms of cord pressure in the above and other cases is hemorrhage from the vessels of the cord (hematomyelia) (see page 853) or its membranes (hematorrhachis). The latter is most frequently epidural; less often subdural. In either case it may occur in considerable volume and extent, but in the epidural variety the amount is not often enough to cause compression of the cord. Hematorrhachis practically never occurs apart from injury, especially fracture, and it almost never exists as an independent lesion. The presence of the subdural variety may be demonstrated by a lumbar puncture. Otherwise we cannot recognize hematorrhachis clinically. There may be symptoms of partial sensory and motor paralysis, which are commonly of only short duration and pass away after absorption of the blood. No operative *treatment* is indicated.

The *symptoms* of these more severe sprains and contusions of the back are a combination of those of the injury to the spine (page 851) and those due to the lesion of the cord. At first there is shock of varying intensity. The swelling is more marked and the ecchymosis more constant than in the less severe cases. Occasionally there is a hematoma. In not a few cases there is rupture of the kidney with blood in the urine. There is no displacement or deformity of the spine, except occasionally a gap between the spines, into which the finger may be placed, and in rare cases a kyphosis, as mentioned above. The shock is treated by stimulants and heat. After the local pain and tenderness are relieved by hot, cold, or wet applications, and morphin, if necessary the treatment is the same as after all sprains of the back, *i. e.*, rest and fixation (page 851).

Concussion of the Spine; Railway Spine.—Concussion as a clinical and pathologic condition does not exist in the cord as it does in the brain. The cord is too well protected against such a lesion. Concussion of the brain is of brief duration, but if cord symptoms develop as the result of injury, their permanence or their slowness to subside indicates gross changes of structure. The mental effects known as shock, fright, or terror are the important elements in the clinical picture of the condition known as "concussion of the spine" or "railway spine." It has no gross lesion, but is a functional nervous disorder or neurosis. The various conditions resulting from such accidents are described under the term "traumatic neuroses" (Oppenheim). They include three types, traumatic neurasthenia, traumatic hysteria, and unclassified forms and mixed types. In addition, there may be symptoms referable to a contusion or sprain of the spine and occasionally to a gross lesion of the cord.

The **symptoms** may come on at once after the accident or not until after a considerable interval. A period of unconsciousness may occur at first. For weeks sleep is disturbed by horrible nightmares and sleeplessness is a common complaint.

Later there are pains and tenderness at various points, stiffness and lameness of the back, and the varied symptoms of traumatic neurosis. (See Chapter XXXIII.) After the contusions and sprains of the back and other physical injuries which may be present at the outset are recovered from, the condition becomes a neurologic and not a surgical one. Of course, there may be actual fracture or dislocation of the spine, but they do not differ *per se* from similar injuries from other causes.

Treatment.—The first essential is rest both of body and mind. Apart from the treatment of any contusion or sprain of the spine, as already indicated (page 851) the treatment is that of traumatic neurosis (Chapter XXXIII).

Hematomyelia.—In hemorrhages of the cord accompanying its crushing in spinal fractures most of the blood escapes externally and of itself causes no symptoms. That which is extravasated in the central part of the cord in the immediate vicinity of the crush may account for a zone of dissociated anesthesia in some cases. In other cases infiltration of blood may gradually extend up the cord and account for the extension of the symptoms above the level of the lesion. The form with numerous disseminated foci is not included, as it cannot be recognized clinically. Occasionally (in 10 per cent. of cases[42]) hematomyelia occurs without traumatism (spinal apoplexy).

Primary focal hematomyelia as the result of injuries of the spine not infrequently occurs without clinical signs of dislocation, and is more common than formerly supposed. Thorburn[43] found 6 cases out of 21 cases of injury to the lower cervical region. Practically it is confined to the lower four cervical and the first dorsal segments, which lie beneath the lower four cervical spines, in the region of the summit of the arch formed by the cervical curve and of the greatest spinal movement. A few cases have been reported in the upper lumbar region. For the pathology see page 657.

Etiology.—The cause is almost always a sudden forced movement, flexion or extension, of the neck, such as may occur in diving into shallow water, etc. This causes an over-stretching of the cord, or distortion and rupture of one or more blood-vessels. There may be no discoverable spinal lesion, a diastasis or partial dislocation with recoil,[43] or a fracture or dislocation. In the latter case it is probably not caused by external compression, as the symptoms are not in accord with that lesion.

Symptoms.—These are due to the circumscribed central hemorrhage, which destroys some of the cord tissue in the immediate vicinity of the hemorrhage and compresses the parts of the cord adjacent to this area. The former may leave permanent results; the latter causes only temporary symptoms, unless the pressure is long continued. In addition, there may be pain, tenderness, stiffness, and swelling in the neck as the result of the injury. The symptoms vary with the extent of hemorrhage, but commonly are as follows: Motor paralysis, as a rule, occurs at once. That due to the destructive lesion, from the position of the latter, is found in the forearm and hand, sometimes in the upper arm. It is a flaccid paralysis, with muscular atrophy and degenerative electric reactions. More or less of this paralysis persists, but one of the features of these cases is the comparatively early and rapid recovery from the paralysis of the lower extremities, which is due to the pressure on the long motor tracts by the clot or the accompanying edema. This paralysis, at first flaccid, soon becomes spastic, the knee-jerks, at first diminished or lost, become exaggerated, and ankle clonus is added. Below the level of the lesion there is, as a rule, thermo-anesthesia and analgesia, one or both, dissociated from tactile anesthesia, as in syringomyelia. The thermo-anesthesia is usually more constant, more marked, and more slowly recovered from than the analgesia. Pain may be referred to the site of the lesion or it may be altogether absent.

As the ciliospinal centers are involved, myosis is regularly present, but is often more marked on one side, when the hemorrhage is not quite symmetrical. Other symptoms of pressure paralysis, such as retention of urine, incontinence of feces, bed-sores, etc., may be observed or not, but are usually of short duration.

In the most severe cases the symptoms are those of a complete transverse lesion, and the result may be fatal. There is then total and not dissociated anesthesia. On the other hand, if the hemorrhage is small the paralysis may involve the upper extremities chiefly or only, as in diplegia brachialis, and the knee-jerks may be exaggerated from the first. Bed-sores do not occur and the bladder and rectum may not be involved in mild cases. If the clot is on one side the Brown-Séquard type of paralysis is seen, the loss of the sense of pain and temperature being on the side opposite the hemiplegia.

Diagnosis.—The chief diagnostic guide at first is the dissociation of the sensation of touch from that of temperature and pain. Later the tendency to improvement of the paralysis, especially of the legs, at an early date, the rapid return of sphincteric control, and the usual absence of bed-sores confirm the diagnosis. The diagnosis is difficult or uncertain only when the hemorrhage is very small or very large. In the former case, if it is confined to the anterior horns there may be no sensory symptoms, only an atrophic paralysis of the upper extremity. If the hemorrhage is confined to the posterior horn, the dissociation of sensation and the thermo-anesthesia might be overlooked, there being no paralysis. When the hemorrhage is large, the symptoms are apt to be those of a complete transverse lesion; but even here, unless the lesion is speedily fatal, an early and perhaps rapid improvement of the paralysis of the lower extremities may suggest the nature of the lesion.

The **prognosis** as to life and function is proportional to the amount of the hemorrhage. In general, it is good. Few cases die, and the degree of possible recovery is surprising. The early return of sphincteric control, the rapid return of motion in the lower extremities, and the absence of the tendency to bed-sores, all indicate a good recovery. The degree of atrophic paralysis that remains in the arms varies with the amount of nerve tissue destroyed by the lesion. The lower extremities may recover completely, or at most with only a slight spasticity.

Treatment is expectant. Operation is not indicated. No treatment will improve the paralysis, which ultimately persists.

Compression of the Cord.—Chronic compression has been described under Intraspinal Tumors (page 838). Acute compression is treated under Fractures and Dislocations of the Spine (below). Pressure from within the cord is considered under Hematomyelia (page 853).

Fractures of the Spine.—The spongy vertebral bodies, increasing in size from above downward, to accommodate the varying weight and strain to which they are subjected, are liable to fracture by compression when the pressure on a part or the whole of their surface is greatly increased in excessive bending of the column or in falls, etc. The elasticity of the column of bodies, due to the intervertebral discs and the double antero-posterior curves, resists the effect of such compression unless it is excessive. The bodies are also subject to a tearing fracture in hyperflexion, etc., which is usually oblique from above and behind downward and forward. The bodies are locked by the articular processes postero-laterally so as to prevent displacement of one body on the other, unless the violence sufficient to fracture the bodies may cause a dislocation or fracture of these processes. Over half of these injuries are a combination of fracture and dislocation, and are often spoken of as "fracture-dislocations." In perhaps 20 per cent. of the injuries the lesion is a pure dislocation, and in the remaining 20 per cent. a pure fracture. The more dense arches and spinous processes may be fractured, often alone, by direct violence; at other times in connection with a fracture-dislocation. In most fractures of the spine many of the ligaments and muscles which hold the vertebræ so firmly together are badly torn.

Fractures of the spine are not common; 0.5 per cent. of all fractures in Stimson's table. Like other fractures, they may be simple or compound, and due to direct or indirect violence and, very rarely, to muscular action. The fracture of itself is not particularly noteworthy or serious. It derives its importance and chief interest from the more or less complete crushing of the contained spinal cord. The latter is so safeguarded against such a lesion that it can occur only when there is, or was at the time of the injury, a considerable displacement of the spinal fragments.

Fractures of the spine are much more common in males, and in middle life, as adult males are more exposed to such injuries as produce them. Although fracture may involve any region of the spine, the great majority of fractures occur in two regions—an upper, including the fourth, fifth, and sixth cervical vertebræ, and a lower, including the last two dorsal and first lumbar vertebræ. Two, three, or even more vertebræ are not infrequently fractured at the same time, especially in the cervical and upper dorsal regions. Fractures of the bodies are more frequent than those of the other parts of the vertebræ in the ratio of 2 to 1. The frequency of fractures of the bodies increases from above downward, so that they comprise about one-half of cervical fractures and more than three-fourths of dorso-lumbar fractures.

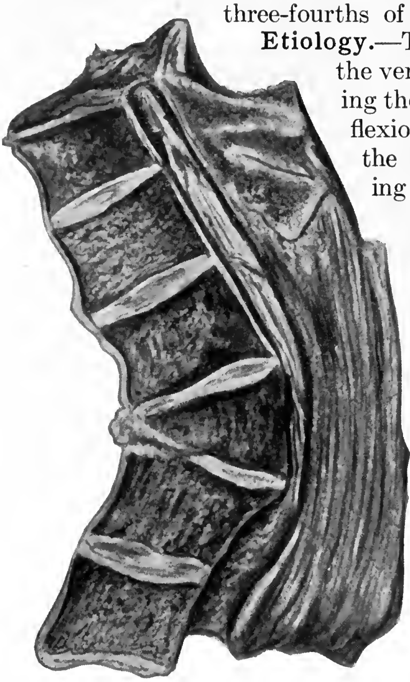

Fig. 564.—Compression Fracture of Ninth Dorsal Vertebra (Hahn).

Etiology.—The commonest cause of fracture of the vertebræ is some violence forcibly bending the spine, most often in the direction of flexion, as by a fall or a falling object or the doubling up of the body, as in driving under a low archway. In falls or blows upon the head or neck the upper part of the spine is more likely to be damaged, and in falls upon the feet or buttocks the lower section. Compression fractures may also be due to any force acting in the long axis of the spine, such as falls or objects falling on the head or shoulders. Practically such a force is generally combined with flexion, ultimately if not at first, for the compression of the bodies causes a flexion of the spine or may be due to it.

Direct violence, a less common etiologic factor, usually involves the spinous processes and the posterior arches. Muscular action is a rare cause, but may act as in forcibly throwing back the head in diving into shallow water.

Varieties of Fracture of the Spine.—Kocher in his classification of fractures of the spine distinguishes isolated fractures of the bodies and those of the arches and spinous processes.

Isolated Fractures of the Vertebral Bodies.—These are always compression fractures. Their frequency varies in different regions of the spine with its elasticity, and the latter depends largely upon the intervertebral discs, which are thickest in the lumbar region and relatively thickest in the cervical region. Hence they are rare in the cervical and upper dorsal regions, and are found most frequently at the dorsolumbar junction, where the spongy bodies are large and thick. Compression fractures occur only in those portions of the vertebræ which have a supporting function. In these fractures the bodies of one or more vertebræ are compressed or flattened longitudinally and pressed out at the sides. This flattening is more pronounced in the anterior half of the bodies, so that the latter become wedge-shaped. If the flexion is combined with abduction, one side of the body may be crushed more than the other. The sudden flexion of the spine which results at the site of the injury and the oblique position of the vertebra above the one crushed tilts it up behind and causes a prominence of its spinous process. This gives rise to a kyphosis in the dorsal region or obliterates the lumbar curve. When several vertebræ are crushed, the kyphosis is more rounded and no one spinous process is especially prominent. If the violence is more severe or continued, the flexion of the spine at the point of injury may continue until dislocation of the articular processes occurs. Even then there may be only a sharp bending and very little narrowing of the neural canal, unless the force is excessive and causes a forward displacement of the vertebra above the dislocated joints.

With the crushing of the vertebræ the intervening discs become crushed to a greater or less degree and the peripheral solid portion of the disc may rupture from the compressing force. Exceptionally an intervertebral disc may be crushed without pressure-fracture of the bodies. By the process of repair following crushing of the discs the neighboring vertebræ become synostosed.

In some cases with a similar mechanism there may be true fragments instead of crushing of the body as a whole. This may occur on the upper anterior edge of the body (anterior wedge fragments), from the pressure of the vertebra above. As this pressure is directed downward and backward it may press one or more fragments of the crushed vertebra backward into the neural canal (posterior wedge fragment), which may press upon the cord, but the damage to the cord is apt to be only partial. Similar pressure at a later period may be due to callus formation.

Isolated fractures of the arches, spinous processes, etc., are less common than fracture of these parts with fracture-dislocations. They result mostly from direct violence. Very rarely a spinous process is broken by muscular action. The displacement is downward or laterally and the fracture is not a serious one. Fracture of the spinous process occurs most often in the dorsal region. Fracture of the arch is much more serious, for if it is broken on both sides the violence sufficient to break it may displace the fragment into the canal and compress or crush the cord. The blow fracturing the arch is usually received on the spinous process. Fracture of the arch alone is much more common in the cervical region than elsewhere, and the atlas and axis are not infrequently the site of this lesion.

Fracture-dislocations.—These often represent an advanced stage of *compression fracture* of the bodies, the sharp flexion of which favors the dislocation of the vertebra above. The degree of dislocation or displacement varies from a very slight amount, where the vertebræ are impacted (Kocher), to one completely crushing the cord. When there is displacement the ligaments uniting the arches and their processes are ruptured.

The greatest amount of displacement occurs when a dislocation of the articular processes is combined with a *diagonal fracture* of the vertebral bodies. The line of fracture is almost always from above downward and forward. The dislocated vertebra carries with it the inferior disc and the upper fragment of the vertebra below. A portion of the postero-inferior part of the body of the dislocated vertebra not infrequently remains connected with the lower fragment, so that the fracture extends through two vertebræ. In these diagonal fractures with dislocation the displacement may be so extreme that the upper vertebra comes to lie on the anterior surface of the vertebra next below. Hence in these cases the cord is in greatest danger of serious or total damage. The favorite site of this form of fracture-dislocation is in the upper dorsal and lower cervical regions; Kocher states that it does not occur in the lumbar region. Flexion is a very important element in the production of these fractures, and its effect is greatest where the spine is normally flexed.

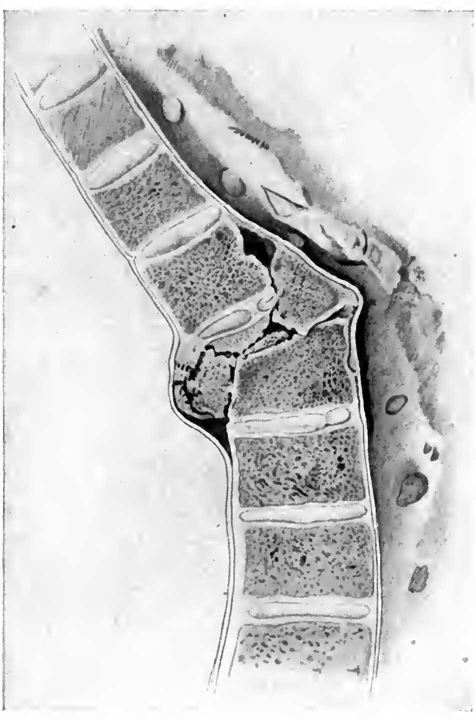

FIG. 565.—COMBINATION OF COMPRESSION AND DIAGONAL FRACTURE OF THE FOURTH DORSAL VERTEBRA (Kocher).

In any fracture-dislocation the articular processes of one or both sides may be broken instead of dislocated. Though this renders the lesion a pure fracture, if it occurs on both sides, the clinical picture is so slightly altered that no separate consideration is necessary. In fracture-dislocations the spinous processes are liable to be broken, especially that of the dislocated vertebra and when the displacement is considerable.

Atypical cases of fracture-dislocation occasionally occur. Exceptionally the line of fracture extends from above and in front downward and backward, with backward displacement of the upper fragment. This may occur in the dorsal or lower cervical region. More rarely the line of fracture is laterally oblique, from extreme lateral flexion with or without previous scoliosis. In fractures and dislocations of the spine the occurrence of suppuration is more common than in other simple fractures.

Varieties of Fracture in the Several Regions of the Spine.—*Cervical Region.*—According to different statistics, from 25 to 36 per cent. of spinal fractures occur in this region. Fractures of the atlas and axis are particularly serious owing to their relation to the medulla and their situation above the phrenic nerve-roots. Owing to the large size of the canal here, fracture alone may not interfere with the lumen, and there may be few, if any, symptoms of injury of the cord, unless there is great displacement. These injuries are not usually immediately fatal; in only 2 out of 11 cases collected by Gurlt in which the lesion was proved by necropsy. Two others died within an hour. The odontoid process and posterior arches of the atlas and axis are the parts most often fractured. The odontoid may be repaired by bony or fibrous union. In the lower five cervical vertebræ fractures of the arches and spinous processes and diagonal fracture-dislocations are common. In the *upper dorsal* region the last-named injury and fractures of the spinous processes are especially common, and compression-fractures also occur. In the lower dorsal region compression-fractures predominate, usually without dislocation.

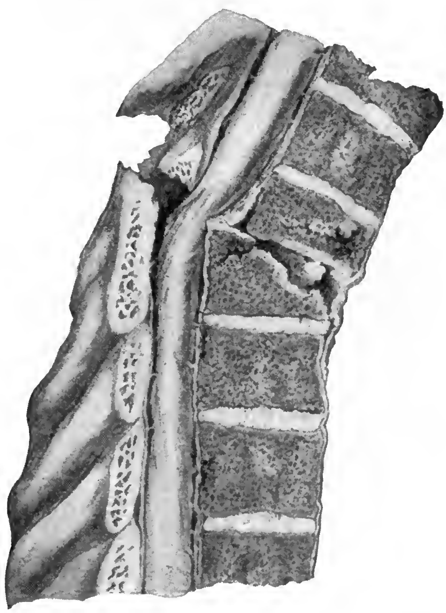

FIG. 566.—FRACTURE OF THE FOURTH AND FIFTH LUMBAR VERTEBRÆ. COMPRESSION OF THE SPINAL CORD (Wagner and Stolper).

The cord is injured by being compressed or crushed between the postero-superior edge of the body of the vertebra below the fracture and the arch of the vertebra above, which is displaced forward. All degrees of crushing occur, from a slight flattening to complete division of the cord. The hemorrhage and edema accompanying the lesion add to the cord symptoms temporarily. That part of the cord which is directly crushed becomes necrotic. Both above and below this area and, in partial lesions, in a part of the crushed zone, the elements of the cord are not destroyed and may, in part at least, recover, if all causes of compression are removed, but degenerate if compression still continues. The central gray matter appears to be more easily and permanently destroyed than the white columns.

Symptoms.—Apart from the varying degrees of shock, which may accompany any severe injury, the symptoms may be divided into (1) those due to the fracture, (2) those due to the injury of the cord, and the inability to stand or sit up, which is due to both.

I. The *symptoms due to the fracture* are those of fracture in general, *i. e.*, localized pain and tenderness, and sometimes mobility, crepitus, and deformity. The pain is dull, constant, and increased by movement or by pressure downward in the long axis of the spine, especially in cervical fractures. It may be wanting. Localized tenderness on pressure is constant over the injured vertebræ and over one in particular. Local swelling is often seen over the site of the injury and may obscure the deformity and interfere with the counting of the spines. In the severer forms of fracture-dislocation, especially where the connecting ligaments and muscles are badly torn, there may be mobility between the two fragments. Crepitus is present where there is mobility. Where the spinous processes or both sides of an arch are fractured, mobility is readily elicited. Except in fractures of the spinous processes no attempt to detect mobility or crepitus should be made, owing to the danger of increasing the injury to the cord.

FIG. 567.—DIAGONAL FRACTURE-DISLOCATION OF FOURTH AND FIFTH DORSAL VERTEBRÆ (Kocher).

The deformity is often a useful sign. The displacement is best recognized by the spinous processes. In the majority (68.1 per cent.[47]) of fractures of the spine the concavity of the lumbar or cervical regions is diminished, obliterated, or replaced by a slight convexity, or some kyphosis is present in the dorsal region. In examining the spine for deformity, irregularities in the contour found in normal subjects should not be mistaken for a kyphosis due to fracture. In compression-fractures the spinous process of the vertebra above the injured one forms the apex of the kyphosis, until several vertebræ are crushed, and then the kyphosis is more rounded. In fracture-dislocations the apex of the kyphosis corresponds to the spinous process of the broken vertebra or, if this process is broken, the next one below. Owing to the sharp flexion, the spines and arches are unusually separated from one another opposite the injured bodies. The forward displacement of a vertebra is indicated by that of its spinous process. There may also be some lateral deviation of the spines at the seat of injury. In fractures of the arches or spinous processes the latter may be depressed, deviated to one side, or displaced downward. In fracture-dislocations of the upper four cervical vertebræ the displacement of the bodies may be made out through the pharynx.

It is not very uncommon to find little or no deformity present on examination, even when the cord is seriously crushed, for the maximum displacement occurs at the moment of injury and is partly or sometimes wholly reduced. Chipault[44a] maintains that bony pressure within the canal is more common, in fact, is the rule, and that its absence at autopsy is a post-mortem change. Of these signs the only ones of service in localizing the position of the fracture are the local tenderness and the deformity. Fractures of the sternum, usually between the manubrium and body, frequently accompany fractures of the spine, due to flexion.

Fig. 568.—Complete Dislocation Forward of Sixth Cervical Vertebra (Kocher).

II. The *symptoms of injury to the cord*, when present, overshadow in importance all other symptoms of spinal injury. They are due to crushing or contusion at the time of the injury, to persistent compression by fragments, blood-clots, or effusions, and at a later period by callus and the products of inflammation. Hematomyelia not infrequently occurs with fracture of the spine in the lower cervical region, with or without other injury of the cord. The symptoms are the same for fractures and dislocations, and vary from those of a complete crush to those of a slight acute compression. The most important cord symptoms, and those that serve best to indicate the level of the lesion and its degree of completeness, are the motor and sensory paralysis and the condition of the reflexes.

Motor Paralysis.—In complete transverse lesions of the cord there is immediate flaccid motor paralysis of the parts below the level of the lesion, without rigidity or spasm of the muscles.

In partial lesions the onset of paralysis may be less rapid, its distribution irregular, and its degree variable. The paralysis often shows a predilection for the extensors; it may soon improve or it may be merely a weakness from the outset. Again, it may affect one side more than the other, but all muscles below the injury on one or both sides are at least weakened at first.

The character of the paralysis varies with the situation and degree of the lesion. In lesions of the lower lumbar and sacral segments the paralysis is flaccid, with rapid atrophy and degenerative electric reactions. In all regions the paralysis is flaccid at first if the lesion is extensive. But when recovery begins, or from the outset in slighter lesions, the paralysis is spastic in dorsal lesions and spastic in the lower extremities and flaccid in the upper in cervical lesions. During recovery contractures are liable to occur from excess of muscle tone in the flexor muscles.

Sensory Paralysis.—In complete transverse lesions the area of anesthesia involves all forms of cutaneous sensibility. It is sharply marked and its level is quite a little below the lesion, because of the downward intervertebral course of the nerve-roots to their foramina of exit, and because of Sherrington's law (see page 842). In some very severe and crushing injuries the nerve-roots, which are much more resistant than the cord, are crushed on one or both sides. When this occurs the anesthesia extends up about to the level of the lesion. This condition helps us in the diagnosis of a complete transverse lesion.

Above the area of anesthesia is a strip of hyperesthesia, pointing to root-irritation, and between these two areas may appear a strip of thermal anesthesia and analgesia which indicates central hemorrhage or other central lesion above the crushing lesion. Exceptionally this dissociated anesthesia is more extensively distributed. In some cases the level of the anesthesia is oblique, indicating an oblique lesion or the crushing of the nerve-root on one side only.

In partial lesions the level of the anesthesia may not correspond to that of the paralysis, and the former may be incomplete (diminished sensation) or irregular in distribution. In such cases, or in recovery from anesthesia, hyperesthesia and paresthesia are often marked and may be signs of recovery. Anesthesia is more speedily recovered from than motor paralysis. Sharp, shooting root pains occur in partial lesions from pressure on the roots within the foramina or canal. They are usually induced by movements of the extremities or the spine, and finally disappear.

The symptoms of paralysis which follow an injury after a short interval are generally due to hematomyelia. Extension of the paralysis above the level of the lesion is due to the same cause or to ascending myelitis.

Reflexes.—The knee-jerk is lost or diminished in lesions of the second, third, and fourth lumbar segments. In injuries above this point they are usually lost at once and permanently in complete crushing lesions. Such a loss of the knee-jerk has been taken as an indication of a complete crush of the cord and a contraindication to operation, but of itself it cannot be so regarded. Exceptionally the knee-jerk is present after complete crushing lesions.[45] In general, the longer it remains absent the more severe the lesion. In the recovery from the cord lesions the knee-jerk becomes exaggerated, and in partial lesions it may be exaggerated from the outset. Ankle clonus usually occurs with exaggerated knee-jerks. The plantar reflex is lost in lesions of the upper three sacral segments; in higher lesions it is reversed and becomes the Babinski reflex. The superficial reflexes are variable and of little value. They are commonly lost in complete lesions.

The *bladder and rectum* are always affected together. Their spinal centers lie adjacent to one another in the fourth and fifth sacral segments. Retention of urine occurs in the greater number of spinal cord injuries, from paralysis of the detrusor urinæ muscle. The sphincter is not paralyzed, but in time becomes relaxed, so that retention gives place to incontinence, which may take the form of intermittent or constant dribbling. There is usually no sensation of the desire to urinate. The paralyzed and distended bladder cannot be emptied without the use of the catheter or drainage of the bladder. In spite of great care, cystitis, often of a severe desquamating type, and subsequent ascending infection of the kidney, are likely to occur sooner or later. In some cases there are no vesical symptoms or, after being present, they subside after a long or shorter interval. This is a sure indication that the lesion is partial and the prognosis is good.

Loss of control of the sphincter ani, readily determined by insertion of the finger, causes incontinence of feces. At first there is usually obstinate constipation, and in dorsal and cervical lesions tympanites, from paralysis of the sympathetic, which may embarrass the respiration. Later on, in severe lesions, constipation gives way to incontinence. The patient may have no sensation of the movements of the bowels or, having sensation, may be unable to control defecation, especially if the stools are loose. Priapism is common in high lesions, especially when severe. It may occur only on passing the catheter or some such irritation.

Trophic and Vasomotor Symptoms.—The skin is dry from lack of sweating, though it may be congested. Eventually the paralyzed parts are cold to the touch. There is usually some elevation of temperature in lesions high up in the cord; and the higher the lesion, the higher the temperature. As a combined result of anesthesia and trophic and vasomotor disturbance in parts exposed to pressure, bed-sores are prone to occur, especially in severe cord lesions, except hematomyelia. They develop rapidly, and, together with the sequels of infection of the bladder, are the common immediate cause of death in most fatal cases.

The symptoms as observed shortly after the injury are liable to some variation after three or four days. While, on the one hand, improvement may commence in partial lesions, on the other hand, the symptoms may indicate an extension upward of the lesion which is due to myelitis.

Regional Variations in the Symptoms.—*Cervical Region.*—In dislocation-fractures the head is bent forward and presents a striking deformity, if the patient recovers. Sudden movements are apt to increase the injury to the cord, perhaps with a fatal result, in the upper half of this region. The injury of the sympathetic fibers distributed to the eye causes paralytic symptoms consisting of contraction of the pupil, narrowing of the palpebral fissure, sinking in of the eyeball, and loss of the pupil reflex.

Transverse lesions of or above the fourth segment are at once fatal from asphyxia, from paralysis of the phrenic. In cervical lesions below the fourth segment the breathing is entirely diaphragmatic. Thorburn called attention to the almost pathognomonic position assumed by patients in whom the cervical cord is crushed just below the fifth cervical nerve. This posture, shown in Fig. 569, consists of abduction and outward rotation at the shoulder and flexion and supination at the elbow, as muscles producing these movements are the only ones not paralyzed (see table, page 866). Priapism is more frequently present and more marked than in lesions lower down. One side is often more paralyzed than the other, the lesion being unsymmetrical. In lower cervical injuries the symptoms of hematomyelia are not infrequently present alone or with other symptoms of injury of the cord, and dysphagia may occur if there is much displacement.

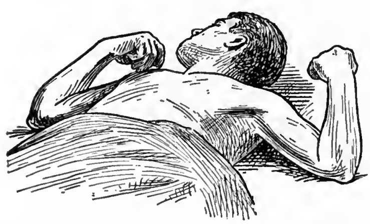

Fig. 569.—Lesion of Spine Between Fifth and Sixth Cervical Vertebræ.

Note position of arms, due to paralysis of subscapularis. Biceps brachialis anticus, supinator longus, and deltoid muscles intact. Elbow flexed, shoulders abducted and rotated outward (Scudder, after Thorburn).

The *dorsal region*, surgically considered, comprises the first to the eleventh dorsal vertebræ which protect the dorsal segments below the first. Fractures here are not very frequent and the symptoms present nothing exceptional. Total injuries of the cord are common.

Lumbosacral and Cauda Equina Lesions.—The lumbar and sacral segments lie within the eleventh and twelfth dorsal and the first lumbar vertebræ, which are more often fractured than any other three vertebræ. In fact, over half the fractures occur below the tenth dorsal vertebræ. In any injury of this region the cauda, whose roots envelop the lumbosacral cord, is liable to be injured. Transverse lesions of this region involve motor and sensory paralysis of the bladder, rectum, and sexual organs. It is often difficult or impossible to distinguish between transverse lesions of the cauda and of its segments from the focal signs alone. In cord lesions there is, as a rule, no pain, while in lesions of the cauda shooting pains or hyperesthesia often occur, especially during recovery and in an area above the anesthesia. In the latter lesions the anesthesia may be less complete, more irregular, in fact, almost wanting, while paralysis is widespread, atrophy is less pronounced, and recovery is more likely than in cord lesions. Asymmetry of symptoms points to a lesion of the cauda. The knee-jerk is not lost if the lesion is below the fourth lumbar segment and its roots. In pure lesions of the conus there is paralysis of the bladder, rectum, and perineal muscles, and anesthesia of the penis, scrotum, and a saddle-shaped area over the buttocks. The cauda resembles a group of peripheral nerves, and hence is more resistant to injury than the cord.

The **diagnosis** of the existence of a fracture of the spine presents difficulties only in some cases of slight severity (isolated fractures), without symptoms of injury of the cord. Here the nature of the violence, the local pain and tenderness, the pain on movement, and the deformity, if it exists, are the main diagnostic points. Marked deformity renders the diagnosis easy, but it is just in these less severe cases that there may be no deformity or it disappears in the supine position or may be overlooked in the lumbar and cervical regions. This is especially likely in cases of slight compression fractures in which the deformity reappears in the erect posture, and the case may be classed as one of traumatic spondylitis. In all such cases the x-ray may be very serviceable, easier to obtain, and less objectionable than in severe cases, when any unnecessary movement may have serious consequences. A fracture of the sternum should always lead to the suspicion of fracture of the spine.

In isolated fractures of the spinous processes or laminæ there will be some deformity in the outlines of the former, also local mobility, and perhaps crepitus. The correct diagnosis is important for the proper treatment, for failure to immobilize the spine may in a few cases allow such a displacement as to cause compression of the cord.

In the severer cases of fracture of the spine not only are the signs of fracture more pronounced, but in addition the symptoms of the injury of the cord render the diagnosis certain. The diagnosis between the several varieties of fracture and dislocation is not usually easy. In cases with a lesion of the cord two questions call for an answer, *i. e.*, (1) What is the level of the lesion? and (2) Is the injury to the cord partial or complete?

The *level of the cord lesion* is determined chiefly by the extent of the motor and sensory paralysis. By comparing the muscles paralyzed, or in the cervical region those remaining unparalyzed, with the table on page 866, the level of the lesion may be determined. This table is taken from Bailey[44] with some alterations. As the more simple table of Thorburn, based on clinical data only, has stood the test of actual use and is more easy of application, those muscles have been put in italics which agree with Thorburn's tables, and any muscles given by Thorburn under a given segment which are not given in Bailey's table have been placed in brackets.

In this examination it should be remembered that each segment contains nuclei for several muscles, and also that the nuclei of each muscle are contained in two or more segments. Adjoining muscles supplied by the same nerve do not necessarily have nuclei in the same segment. The paralysis which serves in the localization of the injury is that of the muscles whose nuclei are in the uppermost segment injured by the lesion, hence it is a flaccid paralysis with rapid atrophy. (See alse page 861.) The examination of the motor as well as the sensory paralysis should be made shortly after the injury, before myelitis supervenes and involves paralysis above that of the injury. Our best means of diagnosing the level of the lesion is the level of anesthesia, which may be applied by comparing it with the diagram (Fig. 560).

Segments.	Muscles.
C. IV.	*Diaphragm.* *Supraspinatus.* *Infraspinatus.* (*Teres minor* [?].) Biceps. Deltoid. Supinator longus. Rhomboids. Scaleni.
C. V.	*Biceps.* *Brachialis.* *Deltoid.* *Supinators.* Spinati. Pectoralis major. Serratus magnus. Rhomboids. Scaleni. Teres minor.
C. VI.	(*Subscapularis.*) *Pronators.* (*Teres major.*) (*Latissimus dorsi.*) *Pectoralis major.* *Triceps.* *Serratus magnus.* Biceps. Brachialis. Extensors of wrist and fingers.
C. VII.	*Extensors of wrist and fingers.* Triceps. Flexors of wrist (?). Pronators. Pectoralis major. Subscapularis. Latissimus dorsi. Teres major.
C. VIII.	*Flexors of wrist and fingers.* Interossei. Extensors of thumb (?).
D. I.	*Interossei.* *Other intrinsic muscles of hand.* Extensors of thumb.
L. I.	Abdominal muscles. Iliopsoas. Cremaster. Sartorius.
L. II–III.	*Flexors and adductors* (III)* *of thigh.* *Sartorius* (III).*
L. III–IV.	Extensors of thigh. *Adductors of thighs* (III).* *Abductors of thigh* (IV).* *Quadriceps femoris* (IV).* Tibialis anticus.
L. V.–S. I.	*Flexors of knee* (L. V.).* *Glutei* (S. I–II).* *Calf muscles* (S. I–II).* External rotators of thigh. *Peronei* (S. I–II).*
S. I–II.	*Calf muscles.* (*Glutei.*) *Peronei.* *Intrinsic muscles of foot.* (*Long extensors of toes and foot.*°) Erector penis (II–III).*
S. III–IV.	*Perineal muscles* (III).* *Ejaculator muscles* (III).* *Bladder* (IV).* *Rectum* (IV).*
S. V.	Levator ani. Sphincter ani.

* Bracketed numbers refer to the segment in Thorburn's table.
° Dorsal flexion of ankle.

After diagnosing the level of the lesion in terms of the segment involved we can determine what part of the spine it corresponds to by referring to Fig. 561. Finally the point of local tenderness over the spine, the position of the deformity, and the use of the x-ray may help in determining the level of the lesion.

Is the Injury in the Cord Partial or Complete?—Can we always surely tell whether the cord has been irremediably crushed or not? The answer to this question is most important in determining the indications for operative treatment. We are forced to admit, in the words of Walton,[46] that "there are no symptoms which establish (otherwise than through their persistence) irremediable crush of the cord," *i. e.*, a crush beyond the possibility of at least a certain degree of repair. It is generally admitted that immediate, total, flaccid paralysis of the muscles whose nuclei lie below the level of the lesion, sharply marked loss of all forms of sensation corresponding to the same level, total loss of reflexes (except perhaps the plantar reflex), retention of urine and feces, and perhaps priapism and tympanites, *if persistent*, without variation and without pain, point to a complete irremediable transverse lesion. But at the onset of these symptoms we cannot say that a certain degree of restoration of function may not occur. "Enough cases have been published, both operative and non-operative, with more or less complete restoration of function after" such "initial symptoms to establish the fact that such lesions are sometimes capable of considerable restoration."[46] I have recently had such a non-operative case in which the symptoms persisted without change for at least fourteen days. Hence the symptoms must persist for a considerable time to establish the diagnosis of complete transverse lesion. Where the symptoms suggest a complete transverse lesion and the level of anesthesia is higher than would be expected from the paralysis (*i. e.*, at the level of the lesion), the intraspinal nerve-roots are probably crushed at the level of the cord lesion. As the nerve-roots are much more resistant than the cord, this implies a degree of crushing violence that would almost surely sever the cord. If the deformity or the *x*-rays show extreme displacement, an irremediable lesion is almost surely present.

On the other hand, in partial lesions some of the above symptom-complex is wanting or it does not persist long without improvement. Paralysis that is incomplete, of slower onset or irregular distribution; incomplete anesthesia, of limited distribution, confined to parts far below the lesion or dissociated; reflexes partly preserved or exaggerated, and improvement in any or all the symptoms indicate a partial lesion.

Prognosis.—When the cord is injured the prognosis is always serious. In Burrell's[47] series (244 cases) the mortality of fractures of the spine was 64.5 per cent.; in Gurlt's (270 cases) the mortality was 80 per cent. The higher the fracture, the worse the prognosis. All cases involving the cord at or above the fourth cervical segments are immediately fatal from failure of respiration. Burrell found a mortality of 85.7 per cent. in the cervical; 76.7 per cent. in the upper dorsal; 56.1 per cent. in the lower dorsal; and 50 per cent. in the lumbar regions. In not a few cervical cases the injury is not severe and the patients improve greatly and are able to get about. In the upper dorsal region the mortality is about as high as in the cervical, for in most dorsal cases the lesion is severe. Hence the patients improve but little, though death is often long delayed. In the lumbosacral region partial lesions are frequent, but return of function is less satisfactory than in the cervical region. Cauda equina lesions give a better prognosis as to life and function, but often show little, if any, improvement. Many of the severer cases have associated injuries sufficient of themselves to cause death.

The prognosis varies with the severity of the lesion. A complete crush, except in the lowest segment, is fatal sooner or later. In the majority of cases, however, the lesion is not total, but some function remains. In the severer cases death usually occurs within five days from shock, complicating injuries of other organs, pulmonary edema, or the results of decubitus or paralysis of the bladder or intestines. Many that leave the hospital alive suffer from a cystitis that may at any time lead to a fatal renal complication. Among the 35.5 per cent. of recoveries in Burrell's series, 62.2 per cent. were useful, 37.8 per cent. were useless. From a comparison of Burrell's and Gurlt's statistics there seems to have been an improvement in the more recent results. This may be partly accounted for by better facilities for preventing or treating bed-sores and cystitis, which are responsible for most of the deaths after the first week. It is also in part due to the inclusion in Burrell's third series of many cases without cord symptoms, bringing the mortality of forty-eight cases down to 37.5 per cent. The most scrupulously careful nursing and care of the skin, bladder, and bowels will favorably affect the prognosis.

Most statistics of cases operated on cannot be taken to prove anything as to the comparative prognosis, for many unsuccessful cases remain unreported, and the cases operated upon are more or less selected. Few cases in which the cord is almost surely completely crushed are operated on. Hence we cannot compare them with the above statistics, as there is no equable basis for comparison. Lloyd[48] collected 185 operative cases; mortality 50 per cent.; recovered and improved, 34.6 per cent. In 82 cases of immediate operation the mortality was 72.2 per cent.; recovered and improved, 20.7 per cent. Among the 167 operative cases collected by Chipault, only 21.5 per cent. recovered or improved. In the 56 cases collected by Thorburn the mortality was 67.8 per cent. Smaller series of cases by a single operator show a high mortality. More recent results are probably somewhat better.

All symptoms indicating a partial lesion (page 866) are of favorable import in prognosis. In cases neither very severe nor very mild a definite prognosis cannot be given for some time. Every improvement is encouraging, and the sooner it sets in, the better the outlook. Exceptionally there may be no improvement for weeks (or even months) after the injury, and then ultimately it is considerable.

Treatment.—All cases cannot be treated alike; each one must be considered by itself. The transportation, undressing, and examination of the patient should be conducted with the greatest care to avoid producing or increasing displacement. The spine should be immobilized by sand-bags. In all cases all weight-bearing should be removed from the spine for six or eight weeks or more by the supine position, traction, etc.

In isolated fractures of the spine without cord symptoms the deformity, if present, should be reduced as far as possible, and the danger of its recurrence or of displacement with resulting injury of the cord prevented by the application of a plaster-of-Paris jacket. This may be easily and quickly done if broad strips of muslin, gauze, etc., soaked in plaster cream are laid beneath the back of the patient and then brought around the body while traction is applied. Reduction of the deformity should be made slowly and carefully by traction in oblique suspension, or horizontally in a hammock or between two tables, or by hyperextension in horizontal suspension on a narrow strip of stout muslin. Local pressure over the kyphosis during traction may assist in the reduction of displaced fragments, but should be avoided if the arch is fractured. The kyphosis due to compression-fractures cannot be entirely and permanently relieved, for it depends upon the flattening of the bodies, and reappears, in part at least, as soon as the patient again assumes the erect position. Unless the kyphosis is reduced as much as possible at first, it becomes fixed by the contraction of the muscles and ligaments, and often by the synostosis of the affected vertebræ, so that late treatment is ineffectual. This same treatment is also applicable, as Burrell says,[47] to cases not hopeless which refuse an operation or on which the surgeon in charge decides not to operate. In applying the treatment by reduction and fixation the open operation should be done at once if any sign or symptom of cord injury appears or if the kyphosis is marked and is not readily reduced. In place of this treatment we may employ continuous extension on an inclined plane, such as a bed raised at the head.

Expectant treatment is indicated when a complete transverse lesion is thought to exist. These cases are hopeless, and fortunately most of them die soon. During expectant treatment, and whenever the cord is injured, certain sequels are to be avoided or treated by prophylactic measures and careful nursing.

To avoid *decubitus* the patient should at once be put on an air-bed or water-bed, care taken to have the sheet free from wrinkles and bread-crumbs, the skin over the sacrum kept scrupulously clean and dry, and both here and over the malleoli or heels, or wherever a bed-sore threatens, the skin should be frequently bathed with alcohol. If it is actually threatened, the part should be protected from all pressure by a ring. (See also Vol. I, page 337.)

The Bladder.—If catheterization is employed, infection is only a question of time, at least in the male. If this occurs, the retained urine, if there is paralytic incontinence, and the vasomotor and trophic disturbances of the bladder wall all favor the development of a virulent cystitis. The latter may be largely prevented by allowing the bladder to overflow from the beginning and avoiding entirely the use of the catheter. Urotropin or similar drugs should be administered continuously to keep the urine sterile. Cystitis has been avoided in the female during three years of catheterization.[50]

If cystitis develops the catheter must be used regularly to remove the retained urine, and the bladder should be washed out with boric acid solution, 2 to 4 per cent., or potassium permanganate solution, 1 : 1000, once or twice a day. Whenever the catheter is used, the strictest asepsis must be employed. Cushing has suggested suprapubic cystotomy with permanent drainage to avoid catheterization, but this is objectionable because of the resulting fistula and the infection which follows in time. It may meet the indications better than the catheter, when the use of the latter is unsatisfactory, especially in young males.

The bowels require to be moved at first by enemata. Tympanites can sometimes be reduced by hot stupes, calomel, massage, the rectal tube, etc. The tendency to contractures should be counteracted by stretching of the affected tendons and muscles, rarely by orthopedic apparatus.

Operative Treatment.—The main benefit to be derived from operation is the removal of pressure. It is indicated in fractures of the arches when these, being driven into the canal and often wedged in, compress the cord. These give the best operative results. It is indicated in lesions of the cauda equina of all degrees of severity to relieve compression and to allow the suture of severed roots. It is also indicated in compound fractures. In the cases presenting the more severe lesions of the cord great diversity of opinion exists as to the wisdom of operative treatment. It is generally admitted that in crushes of the cord with complete transverse lesion operation is contraindicated, for we can accomplish nothing, since repair of the severed cord is not possible. But, as above stated, we have no symptoms by which we can be sure of a complete lesion except by their long persistence. Walton[46] argues that as in a given case we cannot positively diagnose an irreparable crush from one capable of a certain degree of restoration of function, until after the lapse of some time, we are not doing the patient justice if we do not give him the benefit of the doubt and expose the cord. This is essentially the reason Burrell[47] gives for favoring early operation, *i. e.*, that no one can tell the condition of the cord until he sees it, and if pressure exists it will work irreparable harm if it persists many hours. McCosh[51] states that if doubt exists as to the nature of the lesion at the end of twelve to twenty-four hours, it is better to explore, as the danger is slight. Keen[51a] also still favors early operation, for reasons given in an early paper. The comparative safety of operative interference merely represents the lack of a contraindication. Yet a certain number of those operated on early die as the result of the operation, and it is an open question whether the number of these that otherwise would have recovered is not quite as large as of those that die as the result of the expectant treatment that might have recovered after operation.

Many surgeons take a more conservative view.[52] As operation in complete crushes of the cord is useless, therefore when the symptoms of such a lesion, as given on page 867, are present, the patient should be treated expectantly. It is true that in a few happy instances there is a considerable functional improvement after laminectomy in such cases, but so is there after the expectant treatment (page 869). Improvement of function after an operation cannot be positively attributed to the effects of the operation, unless fragments, clots, foreign bodies, etc., compressing the cord, were removed, or the operation was performed late, after improvement had ceased.[53] If the patient shows some improvement after the injury, and this improvement comes to a standstill, then we should operate, but as long as improvement continues it is wise to wait.[51] This position is strengthened by the fact that the damage to the cord in the great majority of severe lesions is produced at the moment of injury, and that, as a rule, at operation nothing causing continuous compression which can be remedied by operation is found. The results in late operations are more favorable than in immediate operations, and in the latter are no better than in treatment without operation.[53] Operation in cases of severe crushing injury is particularly contraindicated if complete anesthesia reaches to the level of the lesion, or if the displacement is so great that the cord could not possibly escape division. In the absence of these contraindications it is sometimes indicated if there is displacement which cannot be reduced by traction. The best surgical judgment appears to justify waiting in case of severe lesions to determine whether or not the cord is completely divided. If improvement occurs, operation is delayed until it is arrested or a retrograde change occurs. Early operation in cases whose symptoms indicate a complete crush is not a life-saving measure, and it is not proved that the degree of functional recovery, if any occurs, is more favorably influenced by it than by the expectant treatment and late operation. There is a revulsion of opinion in regard to early operation in severe injuries, as the results have been disappointing and are no better than without operation. At one time I was in favor of early operation in all cases with cord symptoms, but more recent experience and observation have made me more conservative.

When there is a partial crush of the cord, as indicated by the symptoms or the commencing recovery, the case is altered. Here the injury has been less severe, the cord not completely crushed, and some of the symptoms of the cord lesions may be due to compression by blood-clots, exudate, edema, and loose or projecting fragments, which may be removed by operation. The danger of the operation *per se* is relatively slight, and in these cases, which will live for some time with any proper treatment, the reposition of the displacement or dislocation, and the reduction of the deformity can be much more safely and satisfactorily performed with operation than without it. The removal of slight causes of pressure by operation may affect the degree of recovery so as to make the difference between the invalid chair and the bed, the healthy and the paralyzed bladder, or a useful and a useless condition on recovery.

The question between early and late operation is here of importance. If the injury to the cord is likely to be in part a compression and contusion and not entirely a crush, irreparable degeneration, *i. e.*, pressure myelitis, of intact portions of the cord, is likely to result if the compression is not soon removed. Hence early operation is preferable, for, in addition to preventing unnecessary degeneration, we can correct deformity, by reducing displacement, which is difficult in late operations; in fact, do all that can be done in late operations and more.

A few disregard the shock, claiming that the operation is the best means of treating it, but most surgeons wait till the shock is recovered from. The time that we may safely delay is a matter about which opinion is divided. Some say two, others four days, and others delay still longer. In cases where extension fails to correct the displacement we should operate at once to reduce it and relieve compression.

But in partial lesions with no marked displacement where improvement sets in early, operation is contraindicated as long as it continues satisfactory, since the outlook for a useful recovery is good, and only in exceptional cases of this kind is any cause of compression found and removed at operation. It is also contraindicated if the symptoms indicate hematomyelia. Kocher[52] believes that operation may be safely delayed and advantageously performed after pressure has continued for a long time. In partial lesions late operations are not infrequently followed by good results. Several cases are reported where the dura was found thickened or adherent, probably from hemorrhage, and the relief from the removal of pressure and adhesions was very decided.

The region of the spine injured has some bearing on the indications for treatment. In the cervical and upper dorsal regions operation is rarely of benefit; hence if there is any question of the propriety of operating, it should be decided in the negative. In the lower dorsal and lumbar regions it offers more hope. Although operation is nearly hopeless in acute trauma of the upper half of the cord, Munro[54] has recorded three instances of recovery, and Mixter[55] two after operation on what were considered total transverse cervical lesions before operation.

The *technic* of laminectomy is described on page 845. Laminectomy was first performed in 1886 by MacEwen for fracture. If there are fractured spines, or laminæ, they are removed, taking care not to further injure the cord by pressing the laminæ into the canal. This is preferable to trying to elevate the depressed arches. If there is dislocation of the articular processes, it can be reduced most surely and safely after their exposure, when we can see exactly the effects of the manipulations.

The dura, as a rule, is not torn even when the cord is severely crushed. It should be opened not only to allow the operator to see the cord and the degree of its injury, but to allow the escape of cerebrospinal fluid, or perhaps of blood also. This may do good by relieving pressure or an edematous condition of the arachnoid. The dura should be sutured and no drainage employed beneath it. As the cord may be compressed at two points, by the arch behind and the bodies in front, it is not always enough to remove the former only. If there is any fragment or sharp edge of the bodies pressing on the cord from in front, this may be reached, with some difficulty, by retracting the cord within the dura to one side and then to the other, and removed by chisel, rongeur, or sharp spoon. To facilitate retraction of the cord Chipault tries to hyperextend the spine by cushions under the abdomen above and below the site of operation, and Mills has proposed division of one or two nerve-roots. The latter is usually unnecessary, but if divided they should be sutured. Injured nerve-roots should be treated, like peripheral nerves, by suture. Chipault recommended wiring together the spinous processes or laminæ to prevent the recurrence of the kyphosis of pressure-fractures or the displacement of fracture-dislocations. It is doubtful whether it is efficient for the purpose.

In the after-treatment of all cases, whether the expectant or operative plan is adopted, fresh air, good food, massage, electricity, passive motion, etc., are very important to keep up the tone of the muscles, in case recovery of function should occur.

Dislocations of the Spine.—A dislocation between two vertebræ commonly consists of the inferior articular processes of the upper or "dislocated vertebra" slipping over the top of the superior pair of the vertebra below. This requires the stretching or rupture of the intervertebral discs and many or most of the ligaments between the arches and their processes. In many cases there are associated fractures, especially of the bodies, a thin layer of which, adherent to the disc, may be torn off instead of the disc tearing or separating from the bone. But where the dislocation is the major lesion and the fracture is unimportant, it is classed as a dislocation. Pure dislocations are almost confined to the cervical vertebræ, whose small bodies and relatively flat, though oblique articular processes favor its occurrence. The fourth, fifth, and sixth cervical vertebræ are the ones most often dislocated.

Etiology.—Dislocations are due to an exaggerated movement of the spine, generally in the direction of flexion, sometimes of abduction or rotation, and rarely of extension. The force commonly acts indirectly by a fall or blow on the ends of the spine, sometimes directly over the dislocated vertebræ, and very rarely by muscular violence. Occasionally they occur spontaneously from disease.

Varieties of Dislocation.—*Unilateral Dislocation Forward.*—The lower articular process of one side is raised by lateral flexion, about the opposite articulation as a center, and then by rotation is carried forward over the top of the process below it. Hence it has been termed dislocation by abduction and rotation. Rarely it is due to a direct blow or to rotation from excessive muscular action. The intervertebral disc preserves the approximation of the adjoining vertebræ, but may be partially torn.

The rare *bilateral dislocation in opposite directions* is an exaggerated form of this variety in which the opposite articular process is forced backward by the rotation, after rupture of its capsule; but strictly speaking this process is not dislocated.

Bilateral Dislocation Forward.—By hyperflexion of the neck the lower articular processes are raised up to the top of those beneath them, after the capsular ligaments and those posterior to them are torn. Then the head is crowded down toward the chest, the upper vertebra slips forward, and its lower articular processes sink into the notch in front of the upper processes of the lower vertebra. Kocher[52] believes that isolated bilateral dislocations occur, but practically the intervertebral disc is always ruptured or torn off or the vertebral body fractured (page 858). But in rare cases there is so little forward displacement that there is no injury to the cord.

The bilateral dislocation backward is so rare as to need no special consideration. Only three undoubted cases are recorded.

Distortion or *diastasis* is the same in etiology and in its nature and forms as the several varieties of dislocation, except for the displacement, which is wanting or very slight. The ligaments are stretched and torn, and at the time of the injury the vertebræ are hyperflexed or hyperextended and more or less separated from one another so as to injure the cord by elongation. It is limited to the cervical vertebræ, being most common in the region of the fifth and sixth vertebræ, and is the common cause of hematomyelia. Some nerve-roots may also be lacerated by overstretching.

Dislocation of the occiput from the atlas is rare and of little practical interest.

Dislocation of the atlas from the axis may occur in any of the

Fig. 570.—Fracture-dislocation of the Axis (H. A. Wilson).

forms mentioned above. The commonest reported form has been an incomplete bilateral dislocation forward, in which the anterior arch of the atlas lies in front of the body of the axis. Forward and backward dislocations are only possible after rupture of the transverse ligaments, fracture of the odontoid process, or the slipping of the latter beneath the ligament, after rupture of the check ligaments. All of these three varieties of injury have been demonstrated post mortem. If in the forward dislocation the odontoid is broken and accompanies the atlas, the chances of severe compression of the cord are diminished. This condition is seen in Fig. 570, from a skiagraph of a patient of H. A. Wilson, of Philadelphia. The injury was due to a fall five years before, and there were no cord symptoms. Phillips's[57] case and several others also show that in spite of persistence of deformity life may be prolonged with no marked symptoms, except stiffness and some pain.

The cause of these dislocations has generally been a fall or blow on the head, bending it forward or to one side. They may also be due to violent rotation or suicidal hanging.

Stimson found only one case of injury of the vertebral artery in cervical dislocations, and in that case the processes were fractured and not dislocated.

Dorsal and lumbar dislocations are very rare. One-half or more of them are dislocations of the twelfth dorsal vertebra. The bilateral forward and backward dislocations are about equally frequent. Experimentally Kreiss[56] was unable to dislocate the vertebræ below the fifth dorsal.

Fig. 571.—Left Luxation of Fifth Cervical Vertebra (Wagner).

Symptoms and Diagnosis.—These are much the same as in fracture. As in the latter, there may be no symptoms of injury of the cord, especially in unilateral dislocations and occasionally in bilateral dislocations and dislocations of the atlas with only slight displacement. Local pain and tenderness are common to all forms and may be even more severe on the non-dislocated than on the dislocated side. Pressure from above and active and passive motion are painful, if the latter is at all possible. The absence of crepitus and abnormal mobility are relied upon in differentiating fractures and dislocations. But crepitus is not always present and should not be sought for in fracture, and may be present in dislocations when only a thin layer of the body is torn off with the disc. Rigidity of the spine is the rule in dislocation instead of mobility, but rigidity may be present in fracture by reason of muscular spasm. But, remembering that almost all pure dislocations are in the cervical region, by the study of the rigid attitude, the deformity, and the impossibility of reducing the displacement by pressure, a probable diagnosis may frequently be made, though a positive one is often impossible. The x-ray may be of great service here, as it is more readily applicable in the neck than elsewhere in the spine and in dislocations than in fractures.

The Deformity.—In unilateral dislocations forward the neck may be abducted to either side. In subluxations, where the inferior articular process of the upper vertebra rides upon and not in front of its mate, the neck is bent toward the healthy side. Kocher and Wagner claim that in complete unilateral dislocations the flexion is toward the injured side. Other authorities state that the flexion is toward the sound side. The face is somewhat rotated toward the sound side, unless this is compensated by rotation to the opposite side in the atlo-axoid joint. This rotation cannot be diminished, at the site of injury, by turning the head to the opposite side, but may be increased. In subluxation all movements are possible though painful. The spinous process is rotated toward the injured side, but only those of the lower two or three cervical vertebræ and of the axis can be palpated. The transverse process on the injured side and the corresponding half of the body are prominent in front. The former can often be palpated at the side in the lower cervical region, and the bodies of the upper three vertebræ in the pharynx. There may be a painful prominence on the dislocated side. The muscles of the opposite side are sometimes relaxed and at other times contracted.

In bilateral dislocations forward the neck is usually flexed, especially in subluxations, but it may be straightened by compensatory extension above so that there is no angular flexion, only a depression behind the dislocated vertebra and a prominence corresponding to the vertebra below. The neck above the dislocation seems to be thrust bodily forward, which makes the larynx and trachea project conspicuously in front. The spines, if they can be felt, show this depression and prominence and a diastasis between them. In the upper three vertebræ the anteriorly displaced body can be palpated through the mouth, in the lower part of the neck along the inner margin of the sternomastoid. The above deformity corresponds to a dislocation with slight displacement and correspondingly slight symptoms—what may be termed an isolated bilateral dislocation forward. When there is marked forward displacement the deformity is much exaggerated and the head may be sharply flexed toward the chest. Without operation or autopsy the diagnosis from fracture is usually doubtful. According to Kocher, fracture of the sternum is almost always present in complete dislocations. Occasionally there is dysphagia from pressure on the esophagus.

In distortion there is no deformity, but the pain is generally greater than in dislocation.

In the common *forward dislocation of the atlas from the axis* the chin is depressed upon the chest, the spine of the axis forms a prominence behind, and the anterior arch of the atlas is felt projecting in the pharynx. The head may be abnormally mobile or held rigid. In dislocation in the dorsal and lumbar regions, the diagnosis can rarely be made from fracture. Absence of the tendency to reproduce the deformity after its reduction is one of the best evidences that dislocation had existed.

The *cord symptoms* due to pressure on or crushing of the cord are similar to those of fracture (see pages 861 to 863) in the same region. The degree of the cord symptoms varies with that of the injury, from a complete paralysis to a partial paralysis of motion only. In unilateral dislocation the symptoms are generally slight and often absent, as the canal is narrowed but little. Even in dislocation of the atlas (Fig. 572) there may be no symptoms of cord pressure, owing partly to the large size of the canal, but these may develop subsequently, and usually suddenly from some movement increasing the deformity. When there is severe pressure on the cord, death is instantaneous from pressure on the medulla, usually by the odontoid process. In bilateral dislocations forward the cord seldom escapes, but more often than it is severely crushed. In dislocations of the spine the nerve-root pain, from pressure on the roots in the foramina, is more frequent than in case of fracture.

The injured intervertebral disc commonly softens and is absorbed. The tendency to suppuration, during repair of the lesion, is observed in dislocations, but perhaps not as frequently as after fracture.

Fig. 572.—Rotation Dislocation of the Atlas on the Axis (Kocher).

The **prognosis** in general is bad in cases with symptoms of cord lesion. In the statistics of Blasius of the 159 cases in which the diagnosis was certain, the mortality was 77.4 per cent., *i. e.*, little less than in fractures of the spine. But the great majority of dislocations occur in the cervical vertebræ, and injury of the cord here is more serious than below. Of the 36 cases which recovered in Blasius' tables the dislocation was wholly reduced in twenty-seven and partly reduced in two, which shows the influence of reduction on the prognosis. After reduction of the dislocation the symptoms may subside rapidly or persist in whole or in part. The prognosis is especially bad in the upper three or four vertebræ. In the fatal cases death usually occurs soon after the injury from the lesion of the cord. The prognosis is more favorable in the unilateral than in the bilateral variety, for the cord is less often damaged in the former.

Treatment.—The manner of the reduction of the dislocation is the principal feature wherein the treatment of dislocation differs from that of fracture of the spine. If this is successful, there is no indication for operation. Reduction should be made as soon as possible, for it becomes increasingly difficult and dangerous, and less beneficial if there is pressure on the cord, the longer after the injury it is attempted. Yet it has been accomplished after eight weeks (Richet), and in several cases after a week. In rare cases spontaneous reduction has occurred, especially during the muscular relaxation of sleep. General anesthesia is to be employed, unless contraindicated, for it renders the reduction easier by relaxing the muscles, and therefore safer because less force is required. It also allows a more complete examination. The possibility of instant death from the attempt at reduction in the upper cervical region should be communicated to the family, but should not deter the surgeon from carefully making the attempt, as but one case has been reported in which such an accident occurred.

In *unilateral forward dislocations* traction followed by rotation backward on the dislocated side is usually effective, but Walton's[58] method by lateral flexion toward the non-dislocated side, followed by rotation backward on the dislocated side, should first be tried, as it causes less damage to the non-dislocated side. In this manipulation the non-dislocated side serves as a fulcrum about which the movements of reduction are made. In cases of subluxation no anesthesia is required. Almost complete recovery usually follows reduction. Wagner-Stolper[60] reported twenty-eight cures out of thirty-one cases of this form.

In *bilateral forward dislocations* traction is made, followed by slight extension and pressure backward on the dislocated segment or forward below the dislocation. Or Walton's method may be employed first on one and then on the opposite side, as practised by Hüter, but Wagner-Stolper fears the cord may be injured in this procedure, as its position endangers it, if it has not already been injured. Care should be taken not to increase the flexion, as the dislocation is thereby increased, with consequent danger to the cord.

Although the persistence of the displacement, in dislocations of the atlas, is not incompatible with life and activity, the condition is full of risks, for the displacement may gradually or suddenly be increased by the relaxation of the muscles or by some incautious movement. Hence reduction is imperative by the method of traction, movement, and pressure already described, taking care not to increase the forward displacement or the flexion.

In all these cases counterextension is furnished by the weight of the body or by traction on the shoulders or the lower extremities by assistants. Manual traction is usually sufficient in the manipulation; if not, a towel may be used as a sling. Kocher uses Glisson's sling for extension. In dislocation of the lower cervical vertebræ the movements, especially rotation, must not be made by the head alone, but by the upper vertebræ, otherwise the movements will affect the latter alone. If reduction is not accomplished on the first attempt, the effort should be repeated, if necessary, with more force. Failing in the attempts at reduction, two courses are open: (1) to immobilize with a plaster-of-Paris collar, under extension; (2) to operate and again attempt reduction after the seat of the dislocation is exposed. The latter should be done in all cases below the fourth cervical, with cord symptoms, when several attempts at reduction have failed.

In all cases after reduction redislocation should be carefully guarded against by sand-bags, extension (Kocher), or, preferably, by immobilizing the injured part of the spine by plaster-of-Paris or other stiff dressing. Another method of preventing subsequent displacement, that has been used by Wilkins,[61] Hadra[62], Chipault,[63] and others with some success, is the wiring together of two or more adjacent spinous processes or laminæ. But except perhaps where operation is resorted to to effect reduction, it is wiser to try immobilization first.

The treatment of the symptoms of cord injury, when present, is the same as of those due to fractures of the spine. If the differential diagnosis between dislocation and fracture cannot be made, an effort should be made to reduce any displacement that may be present, and, failing in that, the case should be treated as a fracture.

Traumatic Spondylitis.—This affection, first described by Schede and later by Kümmel, and often called "Kümmel's disease," probably depends upon a non-tuberculous rarefying osteitis of the vertebral bodies. It has also been described as a local osteomalacia. The softening with consequent collapse of the bodies gives rise to a deformity quite similar to that of Pott's disease. It is preceded by an injury of the spine which may be slight or severe enough to cause a compression fracture. Kümmel and others admit that in some cases at least there has been a compression fracture, and that by too early use of the spine the pressure causes a softening and absorption of the callus. Oberst[64] claims that this is the etiology of all non-tuberculous cases. Brodnitz[65] describes a typical case in which a skiagraph after the injury, and again eight weeks later, showed a normal spine, but after the onset of the disease a typical deformity. The injury also is sometimes so slight that the insignificant symptoms subside in a few days. The vertebræ from the third to the seventh dorsal are most often affected, though both the cervical and lumbar may be involved. The first stage is that of the symptoms due to the injury, which last from a few days to several weeks. The second stage consists of a free interval in which the patient may feel entirely well for weeks or months. The long free interval is not compatible with the assumption that all cases are the result of fracture. In the third stage, the disease proper, there is pain at the point of injury and in the nerves radiating from it; tenderness on direct pressure, on pressure in the long axis of the spine, and on motion. A kyphosis develops, usually involving several vertebræ, and more rounded than in Pott's disease, occasionally sharp when only one vertebra is affected. The kyphosis disappears on suspension, but the spinous process of one vertebra remains prominent. The cord is not affected, as a rule, but exceptions occur. In spite of the absence of abscesses and tuberculous processes elsewhere and the difference in the kyphosis, the *diagnosis* from Pott's disease is not always easy at first. The *prognosis* is much better than in the latter condition. In most cases after months of treatment by rest in bed, with traction, and then by supporting apparatus (plaster jacket, etc.), and massage, the process is stopped and the patients recover so as to be able to work. Prophylactic treatment in all injuries of the spine is important.

Stab and Gunshot Wounds of the Spine.—Stab wounds penetrate the canal most often in the cervical region. Here and in the lumbar region the cord may be readily reached by a knife-blade between the laminæ. Both Hahn[66] and Penguiez[67] record cases where a knife-blade remained embedded in the spine for many years. Several cases are recorded where the meninges only were penetrated, so that there was a free discharge of cerebrospinal fluid and the cord escaped injury. The wound of the cord may be on the same or the opposite side to that of the external wound. The lesion is usually a partial section of the cord, causing symptoms of Brown-Séquard paralysis. The symptoms depend in part upon the edema and extravasation due to the injury, and such symptoms disappear in time. The vesical and rectal paralyses are the first symptoms to disappear, and then the paralysis of the legs. The mortality is 40 per cent. for the cervical region and 31 per cent. for the dorsal (Roeseler). There is no hope of functional union of the severed cord, hence no operation is indicated unless there is infection. (See page 870.) The indications for treatment are to make the wound area aseptic, to apply a sterile dressing, and to avoid probing. The cord symptoms are treated as after fracture of the spine (page 870). If a portion of the knife-blade remains in the wound, it should be removed.

Bullet wounds cause compound fractures of the spine, usually without displacement. The arches and processes may be much splintered; the bodies are usually merely fractured or perforated. The cord may not be injured at all, or it may be injured by the passage of the bullet or by splinters of bone due to it. The cord may be partly or wholly severed by the passage of the bullet or it may be compressed or lacerated by splinters or depressed fragments of bone, by the bullet itself, by blood-clots, or by an inflammatory exudate. Hematomyelia may also result from bullet wounds. Subsequently, if the bullet remains in the canal, adhesions and thickening of the dura may result, which of themselves may cause pressure on the cord. In partial lesions the early symptoms partly depend upon edema and extravasation of blood. Very often before reaching the spine the bullet has perforated important abdominal or thoracic organs whose injury alone may be fatal and whose treatment is of paramount importance.

The danger of infection affects the indications for treatment. Bullet wounds in general may be considered aseptic unless portions of clothing are carried in with the bullet or the tract of the latter has passed through the stomach, the intestines, nasopharynx, etc. A bullet in the vertebral body may set up an osteomyelitis, and even if encapsulated, may irritate the cord.[68] The lesion differs from that of a fracture in the absence of a crushing of the cord between the fragments.

The **symptoms** do not differ from those of cord injury in fractures of the spine, varying with the extent and nature of the lesion. Partial lesions and the Brown-Séquard type of paralysis are common. The symptoms may extend above the lesion on account of an ascending central hemorrhage. An important point in the diagnosis is to determine the position of the bullet, which can usually be best accomplished by the x-rays.

Treatment.—If the bullet is in or very close to the canal, or if the bullet tract is likely to be or become septic, it is best to operate early. If the skiagraph shows fragments or splinters of bone in a position to press upon the cord, they should be removed by early operation. If infection occurs, operation is indicated; otherwise nothing is to be gained by operation, as the damage to the cord is done. In cases of complete division of the cord in bullet and stab wounds the tissues of the cord on either side of the lesion are not as contused as in complete crushes due to fracture. Hence they are more suitable for suture of the cord, which does no harm and may help to settle clinically the question of the regeneration of the cord. If no operation is done, avoidance of probing, cleansing of the wound area, an aseptic dressing, and treatment of the cord symptoms fulfil the indications. Operation may be required later on account of the pressure due to callus, cicatricial contraction, or adhesions. Braun[69] removed a bullet from within the cord with a favorable result.

Results.—Prewitt[70] collected 24 cases operated on and 25 not operated on, with a mortality of 54 per cent. in the former and 68 per cent. in the latter. Schmidt[68] gives 62.5 per cent. of cures in cases operated upon and 24 per cent. in those not operated upon. These figures speak strongly in favor of operation, at least when operation is clearly indicated.

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