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DEFORMITIES

INCLUDING

DISEASES OF THE BONES AND JOINTS

VOLUME II

DISEASES OF THE BONES AND JOINTS
PARALYTIC DEFORMITIES

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TORONTO

DEFORMITIES

INCLUDING

DISEASES OF THE BONES AND JOINTS

A TEXT-BOOK OF ORTHOPÆDIC SURGERY

BY

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TO CHRIST'S HOSPITAL, AND TO THE SEVENOAKS HOSPITAL FOR HIP DISEASE
CORRESPONDING MEMBER, AMERICAN ORTHOPEDIC ASSOCIATION

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IN TWO VOLUMES

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TO

MY WIFE

CONTENTS

SECTION V

TUBERCULOUS DISEASE OF THE BONES AND JOINTS

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

CHAPTER VI

CHAPTER VII

CHAPTER VIII

SECTION VI

INFECTIVE DISEASES OF THE BONES AND JOINTS

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

SECTION VII

SECTION VIII

ARTHRITIS AND SPONDYLITIS DEFORMANS

CHAPTER I

CHAPTER II

SECTION IX

OTHER AFFECTIONS OF THE BONES AND JOINTS

CHAPTER I

CHAPTER II

SECTION X

PARALYTIC DEFORMITIES

CHAPTER I

CHAPTER II

CHAPTER III

CHAPTER IV

CHAPTER V

CHAPTER VI

CHAPTER VII

APPENDICES

APPENDIX I

APPENDIX II

APPENDIX III

APPENDIX IV

LIST OF ILLUSTRATIONS

PLATES

FIGURES

SECTION V

TUBERCULOUS DISEASE OF THE BONES AND JOINTS

CHAPTER I

TUBERCULOSIS OF THE BONES AND JOINTS

Definition—Ætiology—Channels of Invasion—Predisposition—Latent Tuberculosis—Local and General Conditions favouring Development of Tubercle—Dissemination of Tubercle—Relative Frequency of Affection of various Joints—Pathogenesis, Pathology, and Anatomy—Appearances in the Bones and Joints—Mixed Infection—Diagnosis of Tuberculous Disease—Differential Diagnosis—Prognosis—Treatment, General, Local, Bier's Method—Para-Articular Tuberculosis.

Definition.—Tuberculosis of the bones and joints is a local disease, presenting symptoms peculiar to the structures in which the bacillus is deposited.

Ætiology.—The manifestations of tuberculosis in human beings, whether visceral, lymphatic, glandular, osseous, or arthritic, are due to infection by the tubercle bacillus of either the human or the bovine type.[1] Thus in 60 cases of tuberculosis in man, investigated as to this point by the Royal Commission, 14 were examples of bovine and 40 of human tubercle. Bovine bacilli were found in 10 cases of primary abdominal tuberculosis, once in sputum, and thrice in cervical tuberculous glands. Bacilli of the human type were found in 8 cases of abdominal tubercle, in 10 of pulmonary phthisis, in 9 of osseous tubercle, and in a number of other cases of affection of various organs.[2] The German Imperial Commission found the bovine type in 10 per cent. Tuberculosis of the glands, bones, and joints preponderates in childhood, whilst phthisis pulmonalis is the essential form in later life. These differences in the regional distribution of tubercle at the various ages are not to be explained by different infective agents, and we cannot say that the bovine bacillus is special to surgical tuberculosis, and the human bacillus to phthisis, as suggested by Nathan Raw.[3] Nor, probably, does infection take

[1] The figures in the text are taken from an interim report. See, however, Appendix I. "On the Final Report of the Royal Commission on 'Tuberculosis,'" for the figures, issued since these data were printed.

[2] Kelynack, *Tuberculosis in Infancy and Childhood*, p. 29.

[3] *Ibid.* p. 35.

place through the intestinal mucosa in the one case and through the respiratory passages in the other, since recent research by Calmette, Guérin, Vansteenberghe, Grysez, Oberwarth, Rabinowitsch, Sir William Whitla,[1] Professor Symmers, and others, show that "Probably at no distant date the contention of Calmette will be accepted, that in the immense majority of cases pulmonary tuberculosis (and more probably surgical tuberculosis)[2] is not contracted by inhalation, but, as taught by von Behring, the germs enter through the intestinal tract." Rather, the discrepancies seen are to be explained by the different reactions of the various tissues to the tubercle bacillus in infancy, childhood, and later life. Certain experiments of Calmette and Guérin will make this clear. In young goats tubercle bacilli of bovine origin were introduced into the stomach by an œsophageal tube. Not until the mesenteric lymphatic glands caseated did the lungs show typical tuberculous lesions. But in older goats the bacilli were found to pass rapidly through the barriers of the mesenteric glands, speedily setting up tuberculosis of the lungs, without leaving a trace of the visible lesions met with in the abdominal glands of the kid. We do not, of course, mean that the effects of infection with bovine bacilli are the same as those of infection with human bacilli, any more than it can be asserted that there is no difference in virulence in various strains of human bacilli; but we suggest that both clinical experience and experiments show that the same seed in different soils produces different results. The soil is not the same in childhood and adult life. Until this line of argument has been worked out, it is unwise to make assumptions based on the results of different seeds on the same soil. At all events the findings of the Royal Commission[3] show that osseous tuberculosis is due to human bacilli, and the practical deduction is that measures directed to the attainment of a pure milk-supply cannot alone be relied on to stamp out surgical tuberculosis.

Channels of Invasion by the Bacillus.—As we have remarked, many investigations[4] point to the intestinal mucosa as the portal through which the bacillus gains entrance into the body. It may

[1] Cavendish Lecture, "Etiology of Pulmonary Tuberculosis," *B.M.J.*, July 11, 1908.

[2] The words in brackets are the author's.

[3] See Appendix to vol. ii.

[4] This is true for guinea-pigs, rabbits, and dogs. In calves, however, Walsen and Titze have shown that, whilst in an infection by feeding with Perlsucht at least 10 mg. was necessary, yet infections by inhalation was established with $\frac{1}{1000}$ part of this dose, viz. ·01 mg. (*Sonderabdruck aus Tuberculose-Abdruck aus dem kaiserliche Gesundheitsamte*, Heft 10, Berlin, 1910).

become arrested in the mesenteric glands permanently or temporarily; or, as the evidence shows, in older subjects pass at once into the blood-stream *via* the thoracic duct. Once in the blood-stream, it escapes into suitable tissue[1] such as red marrow, pulmonary parenchyma, or on its return from the tissues it may be caught by the lymphatic glands. Thus, as Calmette's researches show, cervical adenitis may be due to intestinal infection, and not to more direct infection from the faucial lymphoid tissue. It appears that the bacilli may pass through the mucosa without leaving any signs, and that actual tuberculous ulceration of the intestine is more often due to self-infection by swallowing tuberculous sputum; in which case the dose is much more concentrated.

For a full discussion of infection *via* the respiratory channels, that is, by inhalation, we must refer the reader to special works dealing with phthisis; but, whatever the origin of phthisis may be proved to be, it is clear that in childhood the sequence of origin is usually surgical tuberculosis, and then phthisis, when the two co-exist; whilst in older patients the events are often reversed in point of time, and the pulmonary condition precedes the surgical manifestations.

Other portals of entry are the mucous membrane of the pharnyx, the skin, eye, genito-urinary passages. From what has been said, however, it is clear that great caution is needed in deciding what is or is not a primary manifestation.

In children particularly, the mucous membrane of the nose, the pharynx, and the tonsils, is bounded below by a thick layer of lymphatic tissue. Those who have examined adenoids and tonsils after removal, have in a small percentage, 3-10, found tubercle bacilli deposited therein,[1] and dental surgeons have discovered tubercle bacilli in the pulp of carious teeth.[2]

[1] The human T. B. flourishes better in well-oxygenated tissue, such as the lung; but the bovine requires less oxygen.

[2] The references were kindly supplied to the writer by Mr. J. Lewin Payne, Assistant Dental Surgeon to Guy's Hospital. Starck, *Revue de la tuberculose*, July 1896, was the first to demonstrate clearly that the bacilli, in the case of tuberculous glands, may gain an entrance by the teeth. He quotes the case of a youth who previously had always been healthy, but at the age of eighteen years developed enlarged glands. Carious molars were present on both sides. The glands were removed and the teeth extracted. The glands proved to be tuberculous, and cover-slip preparations from the carious teeth showed the tubercle bacillus. Halle, of Berlin, afterwards showed that the bacillus may gain entrance at times through the living tooth pulp. Odenthal, of Bonn, published statistics of 987 children he examined. In 697 cases, in 70·7 per cent glandular enlargements were present, and carious teeth were associated with the glands in more than half of the cases. Only 7·7 per cent showed carious teeth without glandular swellings. He found that when dental caries existed

The writer is convinced that in children there is another unsuspected mode of invasion. The frequent occurrence of tuberculous dactylitis is explicable by direct infection of small wounds on the hands and feet of young children, crawling on dirty floors. The following sequence of events has been noted by him in a case at the Evelina Hospital for Children—a traumatic ulcer on the dorsal surface of the left first metacarpal bone, succeeded by tuberculous dactylitis, by lymphangitis of the forearm, breaking down at two spots into tuberculous ulcers, then by tuberculous axillary glands, pleurisy localised at the apex of the left lung, and finally by phthisis.

Predisposition.—There is no doubt that ill-health, induced by bad hygienic surroundings or other causes, predisposes the individual to tuberculosis, or, in other words, renders him less resistant to infection. This must not be confused with the vexed question of hereditary or family predisposition to tuberculosis. Until recently the question of immunity had neither been adequately discussed nor sufficiently understood; but, as Kelynack[1] states, "recently, clinical and pathological researches have shown that the character of the soil is of almost equal importance to that of the seed," and he mentions the striking examples of family tuberculosis related by Sir William Whitla.[2] On the other hand, investigations, such as those of Stich, Schnitzlein, and Cornet,[3] demonstrating the rarity of tuberculosis in orphan asylums, show that the hereditary factor cannot be very large. The results of utilising tuberculous cows for breeding, and not for milk producing, in Denmark, rather confirm this.[4] Certain researches even tend to show that tuberculosis in the parent may produce immunity in the offspring. In practice, conditions are such that we are safest in treating

on both sides, glandular enlargements were also present on both sides. Of 267 (28·6 per cent) who had no glandular enlargement, only 5 showed carious teeth. Hoppe, of Leipsic, examined 269 cases. In 73·9 per cent glandular swellings were present, and in nearly all instances were associated with carious teeth. The percentage of children with carious teeth, but without glandular swellings, was 21·5 per cent; 4·4 per cent had neither carious teeth nor glandular swellings. Papers:—Prof. Partsch, "The Teeth and Tuberculosis," *Deutsche med. Woch.*, Sept. 22, 1905. J. F. Colyer, "Oral Sepsis and its Relation to General Diseases," *B.D.A. Journal*, July 1902. G. F. Still, "Medical Aspect of Dental Caries in Childhood," *B.M. Journal*, p. 1485, Nov. 3, 1907. F. Lawson Dodd, "Some Notes on the Relation of Dental Conditions to Tuberculosis," *Trans. Odontological Society*, June 1906.

[1] *Loc. sup. cit.* p. 8.

[2] *A Manual of the Theory and Practice of Medicine*, vol. ii. p. 1299.

[3] Quoted by Kelynack, *ibid.* p. 20.

[4] *Proc. of Tuberculosis Conference*, Lond.

many feeble children as predisposed to infection. Actual congenital tuberculosis of the bones has not been proven.

Latent Tuberculosis.—Tuberculosis in children exists to a much greater extent than is generally suspected, or than the mortality returns indicate. Thus in 1902, in England and Wales, of every 50 children dying under five years of age, at least 3 succumbed to some form of tuberculosis; and Naegeli of Zürich found that in post-mortems on children, under five years of age, 17 per cent were infected. Further, statistics by pathologists in different countries show that, taking all the children dying under fifteen years of age, evidences of tuberculosis will be met with in about 40 per cent. Rokitansky of Vienna, in 11,000 autopsies of patients dying from other causes, found in nearly half of them evidence of healed, quiescent or latent tubercle. The inference is that a large amount of tubercle exists which does not give rise to clinical signs—that is, it is quiescent or healed. Such foci may take on renewed activity if the health of the subject is adversely affected by privation, close confinement, or the exanthemata; and an outbreak of localised or general tubercle follow.

Local Conditions favouring Development of Tubercle.—Of these injury is the foremost. Krause, from statistics gathered from the Clinics of Göttingen and Breslau,[1] found that of 1156 cases of bone and joint tuberculosis, in 271, or 23 per cent, there was ground for supposing that a previous injury favoured the local deposit of tubercle bacilli. Why it should take place in the epiphysis, and less often in the juxta-epiphysial junction, is explained by the facts that these parts are more disposed to injury, and are weaker and softer than the rest of the bone. They are therefore more liable to suffer from strains and wrenches. The peculiar disposition of the blood-vessels in the growing parts also favours deposit of the bacilli. The vessels are large and sinus-like, the blood current is slowed in them, therefore congestion and stasis readily occur. A clot, once formed, is an excellent breeding-ground for tubercle bacilli. The same conditions favour the invasion of a bone by strepto- and staphylococci, and cause acute juxta-epiphysitis, osteomyelitis, and periostitis.

General Conditions favouring Development of Tubercle Bacilli.—Chief among them are the exanthemata, particularly scarlet fever and measles; and the feebleness induced by enteric fever and influenza is a frequent precedent to an outbreak. But

[1] *Deutsche Chir.* L. 28a, S. 161, 1900.

by far the most usual antecedents are bad or insufficient feeding, absence of fresh air and sunshine, dirty homes, and personal uncleanliness. The constant contact of a child with a phthisical parent in whom the disease is active is very likely to result in the acquisition of the disease by the child.

General Dissemination of Tubercle.—A large number of children affected with tuberculous joint-disease ultimately die of general tuberculosis. Wartman, quoted by Nichols,[1] says that after 837 resections of the hip 10 per cent died of general tuberculosis, a result which appeared to have some relation to the operation. In this connection we must allude to the question of the anæsthetic. In some of these cases of general tuberculosis occurring after operation, I observed that ether was given by the Clover method, and that during the early part of its administration a good deal of discoloration of the face and struggling arose from asphyxia. The operations were very slight: two were for dactylitis, and one for scraping a sinus—operations not usually followed by general infection. We suggest that the violent asphyxial movements dislodged tuberculous material in the lung, and multiple emboli followed. At any rate, while it is not reasonable to ascribe the fatal result to the anæsthetic without more definite proof, yet we think that the best anæsthetic in these cases is chloroform, and failing that, the A.C.E. mixture, given on a flannel mask so as to avoid asphyxia and struggling.

Age.—Children are the chief sufferers from surgical tuberculosis; and from five to fifteen years of age is the period of its greatest incidence. We have, however, seen spinal caries at the tenth month, and, on many occasions, before a child was two years old. Nor is the other extreme of life exempt. Many years ago Sir J. Paget described the condition in old people as senile scrofula,[2] and we have seen spinal caries beginning at the age of seventy-two years. It is said[3] that the course of the disease is more rapid and destructive than in the young, but this view does not meet with general acceptance.

Sex.—The male sex is slightly more liable than the female.[4]

The Relative Incidence of Surgical Tuberculosis.—The

[1] *Trans. Amer. Orth. Ass.* vol. xi. p. 357.

[2] *Clinical Lectures and Essays*, "Senile Scrofula," 2nd ed. p. 345.

[3] Bradford and Lovett, *Orth. Surg.* 3rd ed. p. 11.

[4] Gibney, *N.Y. Med. Journ.*, July 1877; Croft, *Clin. Soc. Trans.* vol. xiii.; and Nichols *Trans. Amer. Orth. Ass.* vol. xi. p. 358.

author[1] collected statistics from four of the children's hospitals in London of cases of External or Surgical Tuberculosis admitted during the year 1901. In all 218 cases are reported, and of these 115 were females and 103 were males. The average age was five years and eight months, and the average duration of treatment, previously to admission, was sixteen months. Cases with tuberculous glands of the neck numbered 45, with joint disease 90, with bone disease 64. On these 218 patients 415 operations were performed, or an average of nearly two for each patient. In one case it is noted that as many as eighteen operations were done, on another twelve, and another eleven.[2] As the result of all this expenditure of labour and time, only 68 of the 218 cases, or 31·2 per cent, were cured; 128, or 58·6, were relieved—but relief is no cure in tubercle; in 13 cases the result was doubtful, and 9 patients were known to have died of the disease.

The Frequency of Affection of the Various Joints.—In 210 cases of tuberculous disease of the joints occurring in children under two years of age, Thorndike[3] found 120 to be cases of Pott's disease, 61 of hip disease, and 29 of the knee-joint. Bradford and Lovett,[4] analysing 5950 cases in children under the age of twelve years at the Children's Hospital at Boston, Mass., from 1869-1903 inclusive, found the incidence to be as follows: spine, 2867; hip, 2281; knee, 375; ankle, 394; elbow, 33. These statistics are valuable from the number of cases included in the analysis. More than one joint is frequently involved. Thus tuberculosis of the spine and hip, or, as we have seen, tuberculosis of the spine and both hips, tuberculous dactylitis and spine, or any other combination, may be met with, although for the hip and knee to be affected at the same time is uncommon. We have on two occasions seen, at the Sevenoaks Hospital for Hip Disease, tuberculous coxitis appear in hip-joints, the muscles of which were affected by infantile paralysis. This is sufficiently rare to call for remark. Of all forms of

[1] A. H. Tubby, "Is the Urban Hospital Treatment of External or Surgical Tuberculosis Justifiable?" *Practitioner*, Sept. 1903.

[2] These statistics of operation constitute, in the writer's opinion, a very strong indictment of the urban hospital treatment of tuberculosis. The results are contrasted in this article with those obtained at the Sevenoaks Hospital for Hip Disease, where so many cases are sent after treatment in urban hospitals has failed. In 1901, 42 cases were under treatment; 30 were of joint disease, 10 of the bones and spine, and 2 of enlarged glands. The total number of operations was 3. Fourteen cases were cured outright, and 24 were on the road to recovery; 3 were discharged as incurable, and 1 died of tuberculous disease of the kidney.

[3] *Trans. Amer. Orth. Ass.* vol. ix. p. 196.

[4] *Op. sup. cit.* p. 11.

tuberculous affections, the digital form is the most insidious and far-reaching in its complications.[1] Ménard remarks: "It seems to us that the coincidence of Pott's disease with tuberculosis of one or even two large joints—hip, knee, two hips, two knees—indicates a less sombre prognosis than the tuberculous dissemination through several little bones of the extremities at the same time as in the spine. We have seen patients more often survive two or three large tuberculous foci, than Pott's disease complicated with several little peripheral localisations."

Histogenesis, Pathology, and Anatomy

In the history of the elucidation of the origin and nature of that chronic destructive form of disease of the bones and joints which we now know to be tuberculous, honourable mention must be made of Rokitansky, Virchow, von Volkmann, the writer's revered master and friend, Hüter and Schüller, Robert Koch, König, Krause, and Watson Cheyne.[2] The most authoritative pronouncements on this branch of the subject are the articles by Edward H. Nichols of Boston, and by Sir Watson Cheyne, which are largely used in penning the following description. The important point is that the bacilli can be almost always demonstrated in synovial membrane, granulations, and with less certainty in bone and pus from diseased joints. In examining pus, Cheyne[3] believes that with careful search the bacilli can always be found, though they are few in number. Nichols, however, says "he has been able to demonstrate bacilli sometimes in pus, but usually they could not be found." In bone they are few. In 1889 after decalcification with hydrochloric acid, the author succeeded in finding in a much-eroded head of the femur only two undoubted bacilli after searching through many sections. They were there, but they required patient search. Nichols thinks that decalcification with acids interferes with the proper staining of the bacilli, and in supporting his opinion quotes a simple experiment. Pieces of tuberculous lung, known to contain large numbers of tubercle bacilli, were soaked in 5 per cent nitric acid for varying periods. After two days' soaking the bacilli

[1] *Op. cit.* p. 302.

[2] References will be found to the writings of these authors in the most excellent article by Edward H. Nichols, "Tuberculosis of the Bones and Joints," *Trans. Amer. Orth. Ass.* vol. xi. pp. 353-411.

[3] *Tuberculosis of Bones and Joints*, 1905, p. 80.

stained faintly and in small numbers; after four days no bacilli could be found.

This disease of the bones and joints has been produced in animals by Krause[1] and many others, who injected pure cultures of tubercle bacilli into the joints. Watson Cheyne[2] also injected joints and the nutrient artery of the tibia in goats with similar material, and characteristic tuberculosis followed. In animals the disease followed sprains or dislocation and injection, but never fracture.[3] Nichols suggests in the latter case "the reparative process is so active that the bacillus is destroyed, even if it does obtain access."

Nichols' description of the histogenesis is based partly upon what is known of the development of tuberculous lesions produced experimentally in other organs, and partly upon a study of young tubercles seen in the periphery of tuberculous foci and in miliary tuberculosis. An early tubercle consists of giant and epithelioid cells surrounded by lymphoid cells, the whole being avascular, and the giant cell in the centre is granular or necrotic and stains diffusely. Fat droplets appear in the giant cell and caseation commences. Tubercle bacilli are demonstrable in small numbers in the giant and epithelioid cells. By multiplication of the tubercle bacilli and diffusion into the neighbouring tissues, secondary tubercles are formed; and these coalescing with the original form a visible mass, which undergoes necrosis and caseation. Coincidently with this development, a protective barrier is formed of non-tuberculous œdematous granulation tissue, consisting of plasma-cells, delicate connective tissue, and lymphoid cells nourished by numerous blood-vessels. If the reparative power of the patient is good, this young fibrous tissue hardens and becomes denser, and the blood-vessels in it are seen to be less plentiful. If, on the other hand, the patient has little or no reparative power, the tubercle bacilli invade and transform the young fibrous tissue into tuberculous granulations, and the mass ultimately caseates. Such is the course of events in any tissue invaded by the disease.

In the long bones the disease generally begins in the epiphysial ends and in its marrow, and spreads thence to the bony trabeculæ. It rarely commences in the compact cortical layer, and never in the cartilage. Tuberculous deposit in the marrow, when it becomes visible to the naked eye, is seen as small circular grey or yellow

[1] Krause, *Der Tuberc. der Knocken und Gelenk*, 1891, p. 81.
[2] *Ibid.*
[3] Krause, *op. sup. cit.*

areas surrounded by a thin margin of deep red granulation tissue. Secondary tubercles arise and coalesce. Meanwhile, caseation has been going on in the primary and accessory tubercles, and an irregular cheesy mass is formed surrounded by growing and spreading tubercle. In the destructive process the bony trabeculæ are involved. The caseation leads to the formation of a bone abscess containing remains of the trabeculæ in the form of "bone-sand." Lining the abscess cavity is a layer of granulation tissue, or abscess membrane, a very useful protection against the further spread of the disease. It is not, however, always present; and in old-standing cases the membrane may become hard and sclerotic.

Tuberculous Necrosis.—If the tubercles are deposited in a circle around a given area of bone, that portion dies owing to the cutting off of its blood-supply and forms a sequestrum. Such sequestra are not usually more than 3 cm. in diameter, and are as a rule single. The sequestrum may lie bathed in pus, and the walls of the cavity may be lined either with soft purplish red granulation tissue, or in old-standing cases be sclerosed. When the tuberculous area is wedge-shaped, with its apex towards the epiphysial line and its base towards the articular cartilage, a "bone infarct" has been formed due to blocking of an artery by a tuberculous embolus.

Tubercle may be and is often present in more than one epiphysis of a bone, and, as in the case of the knee-joint, it may be in the articular epiphyses of both bones.[1]

Tuberculous Diaphysitis.—When a long bone possesses an epiphysis at each end of the diaphysis, the seat of election, according to Harold Stiles, for tuberculous disease to attack these bones is undoubtedly the growing extremities of the diaphysis.[2] If the epiphysis is large, and the growing line is situated outside the joint, as in the cases of the upper epiphysis of the humerus and the lower epiphysis of the fibula, the joint often escapes, for the disease either advances along the diaphysis or spreads to the surface of the bone outside the joint. This is one form of the affection. There is a second form mentioned by Stiles, where the disease invades the diaphysis in a diffuse form, a widely spreading tuberculous diaphysitis. Krause[3] also states that he has seen primary

[1] König and his pupils have shown again and again how close the connection is between the localisation of the tuberculous foci and the distribution of the blood-vessels to the large joints and long bones.

[2] *Operative Surgery*, Burghard, vol. ii. p. 3. [3] *Loc. sup. cit.*

PLATE I.

Spina Ventosa (Tuberculous Dactylitis) of the Periosteal Form, affecting the third metacarpal bone of a girl aged 13 years (Alban Köhler).

To face page 13.

tuberculous diaphysitis, but the cases were not verified by autopsy. Until recently the diffuse form was very refractory to treatment, and the cases ultimately resulted in amputation. However, by an original method of treatment, evolved by Stiles, many cures have been obtained. A third way in which the shaft becomes involved is by spreading of tuberculous virus from the epiphysis through the growing line into the shaft.[1] The epiphysis receives its main blood-supply from an artery in the juxta-epiphysial region, which leaves the diaphysis and passes through the centre of the growing line into the epiphysis. It is accompanied by veins which return blood from the epiphysis to the diaphysis. Tuberculous infection may, therefore, be carried from the diaphysis into the epiphysis by the artery, or *vice versa* by the veins.

Tuberculous Disease of the Smaller Long Bones is known as "spina ventosa." It is very common, and is usually seen in the bones of the hands and feet as "dactylitis." It is usually an epiphysitis or juxta-epiphysitis spreading to the medulla of the shaft, which becomes distended and bulbous with new and diseased material. The shell of compact bone and periosteum is expanded, and ultimately the compact bone is attacked and disappears; but, meanwhile new bone, very thin and brittle, is formed from the periosteum (Plates I., II., III.). This lamella and the soft tissues are often perforated by sinuses discharging caseous pus and the remains of bone trabeculæ. The disease also involves the smaller cuboidal bones such as those of the wrist and the feet and the bodies of the vertebræ; and, several bones being implicated, extensive destruction of joints ensues. Of the flat bones, the ribs are most commonly affected, and the scapulæ, clavicle, pelvis, sternum, and even the skull, especially the parietal bones, are sometimes seen to be diseased, more particularly as a condition secondary to dactylitis.

Cold Abscess.—By the gradual spread of the disease in the bone the periosteum is involved, and ultimately the soft tissues. Caseation has by this time commenced in the bone, and by softening of the morbid material in the soft tissues a large necrotic area is produced, which eventually breaks down in feeble subjects into pus, and forms a "cold or tuberculous abscess." It is called cold, because so long as the infection is tuberculous only, no local elevation of temperature is present. But, if it becomes "secondarily infected"

[1] Volkmann, *Klin. Vorträge*, s. 5, p. 1405; Krause, *loc. sup. cit.*; König, *Tub. der Knocken und Gelenk*; Ziegler, *Path. Anat.*, 1892, vol. ii. p. 150.

with pyogenic organisms, the usual effects of "mixed" infections follow, and rapid deterioration of the patient's health, hectic temperature, wasting, and anæmia ensue. The appearance of tuberculous pus in a large abscess is thin and watery, and in it are found fibrinous coagula and pieces of necrosed bone of small size. In a small bone-abscess the pus may be thick and almost putty-like. The pus in an infected abscess is white or white-yellow. Tubercle bacilli are always present in it,[1] although they may not always be found.[2] The walls of a tuberculous abscess are composed of an inner layer studded with tuberculous granulations, and outside this is a layer of secondary inflammatory tissue, which, if it becomes developed into dense fibrous tissue, limits the spread of the disease. Tuberculous fistulæ often form, and their walls are composed internally of diffuse tuberculous granulations, and externally of œdematous granulation-tissue. When the disease invades the skin in the neighbourhood of the mouth of a sinus a very intractable ulcer follows, and is succeeded in many cases by tuberculous lymphangitis and adenitis.

Tuberculous Disease of Joints

An important question, worthy of some discussion, is as to whether the disease begins in the bone or in the synovial membrane. Volkmann[3] believed that in children it began almost without exception in the epiphyses, but that sometimes in adults the synovial membrane was primarily affected. Later writers, or at any rate the majority of them, follow Volkmann. Krause,[4] writing of a series of cases seen *at operation*, says that 23 per cent were primarily synovial. Watson Cheyne states that primary synovial disease is common. Nichols[5] says that he has examined 120 joints in children and adults, and has never seen a joint in which, "if all the bones were sawed across in thin layers, one or more bone foci were not found." But the search must be careful and thorough, more particularly to find the line of extension from the bone to the joint. His opinion is that primary synovitis is exceedingly uncommon, and with this the author agrees.

Extension of Disease from the Bone to Joints and Soft

[1] Nichols states that "he has never failed to produce tuberculosis by inoculating susceptible animals" (*loc. cit.* p. 373).

[2] Krause says "in about one-third of the cold abscesses" (*loc. cit.*).

[3] *Loc. cit.* [4] *Loc. cit.* [5] *Loc. cit.* p. 383.

PLATE II.

Spina Ventosa (Tuberculous Dactylitis) of the Central Form, affecting the third metacarpal bone of a woman, aged 30 years (Alban Köhler). The tuberculous deposit in the medulla has expanded the cortex, so that it is represented by a fine line only. One year after this skiagraph was taken the disease had disappeared, as the result of repeated injections of glycerine and iodoform.

To face page 14.

Parts.—Usually the disease perforates the layer of bone lying underneath the cartilage, and the joint then becomes involved. Occasionally extra-articular perforation takes place.[1] In the latter event the morbid process extends to the surface of the bone outside the capsular ligament, and forms an abscess which bursts into the soft tissues. Such a condition we have seen twice in the hip, where a sinus was found leading into the neck of the femur. In one case the condition was suspected, and was verified by operation and the joint was saved. In the second case it was not suspected, but the joint was also saved by careful scraping and removal of the tuberculous disease.

Before joint-perforation takes place a secondary non-tuberculous inflammation of the articular cavity takes place, and Volkmann describes a condition of non-tuberculous "pannus" of the joint, with obliteration of the joint cavity. Tuberculous pannus with obliteration of the joint cavity is common. The actual steps in the perforation of a joint are extension of disease to just beneath the cartilage, fibrillation of cartilage, absorption of cartilage cells, formation of irregular spaces, and irruption of tuberculous material into these spaces, with resulting infection of the synovial membrane; and these events are hastened by articular movements. Then deposit of bacilli takes place in the subendothelial lymph vessels, and typical tuberculous nodules form. The synovial membrane is infected, thickened, and studded with tubercles. These coalesce and soften, and tuberculous ulcers appear. In addition to the perforation of the cartilage, the advancing disease in the membrane gradually insinuates itself beneath the outer edge of the cartilage and lifts it away from the bone until it gradually necroses. The ends of the bones are then found to be covered with granulation tissue, much of which is tuberculous. The cavity of the joint is generally distended with fluid; rarely it is dry, as in caries sicca, a form of disease seen in the shoulder-joint. The fluid is at first clear, or turbid from the presence of polymorphonuclear leucocytes. Later it becomes opaque, and contains also clots of coagulated fibrin and shreds of necrotic tissues. In effect, a joint abscess has formed.

An *arborescent form of tuberculous synovitis* is met with where long branching arborescent tags, often pedunculated and of considerable size, are seen. Sometimes the tags, which contain tubercle bacilli, are very vascular, or a large amount of fatty tissue is developed in them, the so-called *lipoma arborescens*. Another form

[1] Cf. Remarks on *Para-Articular Tuberculosis*, vol. ii. pp. 50-53.

of synovial tuberculosis is met with in the form of *firm circumscribed nodules,* wart-like in appearance. We have met with one case in a woman, aged 32 years, in whom we opened first one knee-joint and then the other, and removed the growths. The disease subsided, and excellent movement followed. *Rice bodies* are found occasionally, but not so often as in bursæ.

Tuberculous disease in a joint gives rise to thickening of the peri-articular tissues in the form of granulation tissue, which may either become dense fibrous material, or be infected with tubercle and break down in places.

Repair.—Under favourable conditions tubercle becomes self-limited, and repair commences. Possibly, small areas of disease are absorbed, or entirely encapsuled. In any event the repair of larger areas, whether in bone or soft structures, is by the formation of non-tuberculous granulation tissue, succeeded by fibrous tissue. Occasionally sequestra remain encapsuled. The liquid portion of the caseous matter is absorbed, and the inspissated material is replaced by fibrous tissue, or is calcified. Repair of the joints takes place by fibrous tissue (fibrous ankylosis), which may in some cases be converted into bone (bony ankylosis), or less often into cartilage (cartilage ankylosis). Generally an ankylosed joint exhibits all three forms. In many instances the disease is not completely cured, and being latent, it may again light up.

Septic Infection (Mixed Infection of Tuberculous Abscesses).—When tuberculous pus has approached the skin, or if it is very closely in contact with hollow viscera, such as the colon and rectum, infection occurs, but not always. After incision and drainage infection is all too frequent. In the case of a small tuberculous abscess near or at the extremities this is not of serious import. But it greatly increases the gravity of the prognosis in spinal, hip, knee, shoulder, and elbow cases. Once established, septic infection is a dangerous complication. The local symptoms increase, and the part becomes red, more swollen, and more painful. Generally, symptoms of septic absorption appear in the forms of hectic fever, progressive emaciation, amyloid disease, and gradual exhaustion; or general tuberculous dissemination occurs.

Diagnosis and Differential Diagnosis

If the classical signs of tuberculous arthritis or osteitis be present, and those in a youthful patient, there is little doubt about

PLATE III.

Spina Ventosa (Tuberculous Dactylitis) of the Central Form, affecting the first phalanx of the ring finger of a woman, aged 35 years (Alban Köhler). The neighbouring joints have escaped infection.

To face page 16.

the diagnosis. Difficulties may, and do arise, in differentiating gonorrhœal, syphilitic, rheumatoid-arthritic, and malignant cases from tuberculous. It may be that one can afford to wait in order to confirm a provisional diagnosis; yet there is no necessity for this, since many subsidiary aids to diagnosis are now available.

The interpretation by an experienced person of a well-taken radiograph is of value. Epiphysial foci or other changes may be revealed.

Tuberculin, or rather the various tuberculins, may be used in several ways as diagnostic agents. The rationale of these procedures will be rendered clearer by a discussion of vaccine therapy in surgical tuberculosis. In this place we must be content with almost a bare reference to the leading methods. These are—

1. *The Ophthalmo-Tuberculin Reaction of Calmette.*—A ·5 per cent solution of the precipitate obtained from Koch's original tuberculin by means of 95 per cent alcohol is the reagent. The object of the precipitation is to get rid of the glycerin. However, glycerin in such a small amount makes little difference, and Rivière[1] states that old tuberculin dissolved in 3 per cent phenol makes a useful standard preparation. A drop or two is instilled into the eye of the individual to be tested. If a reaction occurs, consisting of more or less conjunctivitis coming on within from eight to twenty-four hours, and lasting some days to a week, tuberculosis is present; if no reaction occurs, tuberculosis is absent, the negative result being more reliable than the positive. On no account must this test be used unless the eye itself is perfectly healthy.[2] Rivière states that the results are as valuable in children as in adults. Advanced cases fail sometimes to give a reaction; but in these, in any case, the diagnosis is not in doubt.

2. *Von Pirquet's Cutaneous Reaction.*—For the description of this, as for many other details dealing with vaccine therapy, we are indebted to R. W. Allen's work, *Vaccine Therapy and the Opsonic Method of Treatment*, Second Ed., London 1908, and to W. D'Este Emery's *Immunity and Specific Therapy*, London, 1909. The reagent is tuberculin 1 part, normal salt solution 3 parts, containing ·25 per cent carbolic acid. The skin of the upper arm is cleansed with ether, and two drops of the solution placed two

[1] Kelynack, *Tuberculosis in Infancy and Childhood.*

[2] Serious results, even to the loss of an eye, have followed careless instillation. Special attention must be given to the lacrymal sac, so as to be sure that no septic organisms are present. W. D'Este Emery (*Immunity and Specific Therapy*, 1909, p. 382) says that the use of "Calmette's test is not justifiable, unless the diagnosis is of great importance, and all other measures have been tried and have failed."

inches apart—a slight abrasion is made with a lancet, which is then disinfected, and a third control abrasion made. If tuberculosis is present, after forty-eight hours redness increasing for a day or two results in the two infected areas, and a papule develops.

The great advantages of this test are that it is reliable in the first three years of life, because in early childhood the opsonic index is no guide. The test causes no constitutional disturbance, and can be used in pyrexial cases. After early life it is less reliable.

3. *The General and Local Reaction following the Subcutaneous Injection of Koch's Original Tuberculin.*—This is a clinical test, the value of which depends on the fact that the injection of a small dose—·1 milligramme in children, ·2 milligrammes in adults—of Koch's old tuberculin does not affect the healthy individual; but in the tuberculous it is followed by hyperæmia and congestion of the affected area, with constitutional signs such as rise of temperature commencing in 8-11 hours, feeling of malaise, headache, and pains in the limbs. The susceptibility to tuberculin varies very much, and rises with each injection, so that a dose which at first produced no results, if repeated, yields a reaction. On this is based the practice of repeating the dose, every three or four days, up to four injections. By repeated and increasing doses the susceptibility is so increased that the healthy react. In any case we must endeavour to use the smallest dose possible, capable of producing a sufficiently marked rise of temperature—that is ·5° C. or ·9° F. A negative result is of value, a positive less so, because this may be due to obsolescent tubercle elsewhere, and have no bearing at all on the actual lesion under observation. The test cannot be used in febrile cases, and the surgeon should not use the test if there is any suspicion of phthisis being present. Of course, if phthisis is known to be present, there is no object in injecting. It seems very uncertain whether cases due to the bovine bacillus will respond to tuberculin of human origin; and it must be borne in mind that the highly tuberculous may not react at all, whilst the non-tuberculous do if the dose is large enough. Further, Sir Almroth Wright's researches show that harm may be done by injecting even a small dose in a tuberculous patient during the negative phase (see later), or at that moment when the powers of resistance, so far as the tubercle bacillus is concerned, are abnormally low. *To sum up*, in the hands of experienced clinical observers the test is of value, but it is not free either from limitations or from danger.

4. *Observations of the "Opsonic Index" from a Diagnostic Point of*

View.—For a full description of the determination of the opsonic index special writings must be consulted; in this place only the briefest mention can be made.

Sir Almroth Wright, by his researches, has shown that there are certain substances existing in the plasma which so affect bacteria present that they more readily succumb to the attack of the phagocytes. The substances he has named "opsonins." In certain respects they are ferment-like bodies. They cannot be isolated, but it is possible to compare the relative amounts present in the blood or serum of different individuals. This relation is the "opsonic index." Leucocytes, or rather blood-cells, washed free from plasma (containing opsonin), are mixed with an emulsion of a given organism, say, the tubercle bacillus, and some of the serum to be tested. The mixture is incubated at 37° C. for fifteen minutes, and the number of bacilli ingested by 100 leucocytes counted, and thus the average number per leucocyte obtained. Suppose, for example, that in testing the serum from the blood of a healthy person we find the count to be 4, that is, 100 leucocytes have ingested 400 bacilli; we now test in the same way, using an exactly similar portion of the emulsion of tubercle bacilli and blood-cells, the serum from an individual the subject of tuberculous knee, and find 100 leucocytes ingest now only 300 T.B. We say that

$$\frac{\text{Patient's phagocyte count}}{\text{Normal count}} = \frac{3}{4} = \cdot 75.$$

That is, the opsonic index is ·75.

In practice, this determination of the opsonic index is rather difficult and tedious; and only those results, which are the outcome of considerable laboratory experience, with a natural aptitude for this class of work, are of any value.

Some of the opsonin normally present is non-specific, that is, it prepares the way for the destruction of not one organism only, but also of others. When, however, the opsonic index is raised, for example, in tuberculous infection or in response to injection of tuberculin, the tuberculo-opsonin alone is increased, but the index to other organisms is not raised.

The following points and tests are noteworthy:—

(*a*) In health the opsonic index for the tubercle bacillus is found to vary from ·8 to 1·2. In chronic localised tuberculosis it averages ·6.

(*b*) The effect on the opsonic index of auto-inoculation by massage, movement, or von Bier's congestion of the part. If a tuberculous knee, for example, is massaged or passively moved, and the index determined every few hours for 24 hours, a rise preceded by a short negative phase will be noted. Thus in a doubtful hip in a child whose opsonic index was ·8, 6 hours after passive movement it had fallen to ·5, in 12 hours it was 1, and in 18 hours as high as 1·1, thus indicating definite tuberculosis. Had the condition been non-tuberculous the index would have remained unaffected.

(*c*) In a tuberculous woman, during menstruation, the index towards the tubercle bacillus is much lower than during the inter-menstrual periods.

(*d*) If the condition is associated with a fluid collection, the fluid has a lower opsonic index than the patient's blood serum. Thus, the contents of a tuberculous abscess have a lower index than the blood itself.

(*e*) The effect on the index of the injection of a small dose of tuberculin, either the old or the new (T.R.):—A dose too small to produce any marked constitutional reaction causes the index to oscillate in the direction of a negative followed by a positive phase, if the individual is tuberculous.

(*f*) The heated serum test depends on the fact that the serum of an immune or infected person loses less of its opsonic power, after heating to 60° for half an hour, than does that of the normal individual. That is, probably, because immunisation is followed by an increased production of a "specific" opsonin; and this specific opsonin is more thermostable than the non-specific opsonin of non-infected blood.

Probably for our present purpose tests *a*, *b*, and *e* will be found most valuable, but in view of the doubt as to which type of bacillus, bovine or human, may be present, it may be necessary to determine the index as regards both; also to inject not only with T.R. of human origin, but with tuberculin of bovine origin, P.T.R. (Perlsucht T.R.), unless a satisfactory or sufficiently marked result is obtained. This difficulty is partly obviated in test *b*, because here the vaccine is autogenous. The index, however, will need to be determined for both forms of bacilli, the extra labour involved being rewarded by the exact information as to the infecting organism—a point of the greatest value if successful vaccine therapy is to be subsequently carried out.

5. *Inoculation of Guinea-Pigs with some of the Suspected Material.*—If tubercle is present, the guinea-pig dies of general tuberculosis in from six to ten weeks. The information yielded by

this procedure is very reliable, and when suspected fluid can be reached by a hypodermic needle, there is no difficulty. But in many cases no material can be obtained apart from operative procedures, perhaps inadvisable at the time. Also, considerable delay must elapse before any conclusions can be arrived at. However, one great advantage is the possibility of using the result for the preparation of a vaccine.

Prognosis.—Osseous and articular tuberculosis under favourable conditions becomes self-limited by the formation of fibrous tissue. All those conditions which increase the patient's resistance to the bacilli, particularly if aided by rest of the joint, promote healing. Moreover, the patient gradually acquires immunity, probably through the anti-bacterial substances developed in the plasma. We shall refer to this in speaking of tuberculin.

As a rule, children respond to treatment more readily than adults. A child, crippled by a tuberculous spine or deformity of a large joint, not only falls behind in the race, but also fails to reach the actuarial expectation of life, even if he completely recovers in childhood from the tuberculous lesion.[1]

The site of the affection is also of importance in prognosis. We shall advert to each instance under its own particular heading. Suffice it to say now that spinal lesions are the most serious, and then the hip. If two foci form in the spine they add to the gravity of the disorder, and such cases demand very prolonged treatment before recovery occurs.

Multiple surgical tuberculosis is also very serious; yet Ménard had under his care a patient who recovered from two foci of spinal caries and arthritis of both knees; and he has under observation two patients with spinal caries and double coxitis, in whom life does not seem to be threatened. That writer is also responsible for the statement that spinal caries is associated with tuberculosis of larger joints less frequently than with disease of the smaller bones, such as the metacarpals and metatarsals; he also adds that the prognosis in the latter class of case is worse, but is unable to give a reason.

Cranial tuberculosis indicates feeble resistance to bacterial invasion; Ménard instances such a case. A girl, aged 14 years, in 1895 had a tuberculous abscess of the cranial vault, followed by arthritis of the knee, of the tarsus of the same side, and of the left wrist. In May 1896 the right wrist became affected, and arthrotomy was

[1] Cf. A. H. Tubby, "Tuberculous Bone and Joint Disease in Children; its Effects on the Duration and Usefulness of Life," *British Journal of Tuberculosis*, July 1907.

done. In July 1896 the left wrist was resected. Then followed disease of the second metatarsal bone, the left tibio-tarsal joint and left knee, the last two necessitating respectively astragalectomy and arthrectomy of the knee. In January 1898 spinal caries appeared, and was followed by an abscess of the left malar bone.

Invasion of the small is not so serious *per se* as of the large bones and joints, so long as the disease remains limited to the smaller structures. Nevertheless, the gravity of tuberculous dactylitis lies in the fact that it is frequently complicated by spinal disease, and these cases run an unsatisfactory course. Still, exceptional cases occur, and Ménard speaks of the recovery of a child affected with disease of the smaller bones and joints and of the larger, after having had in all seventeen visible foci. Finally, the prognosis is largely influenced by the surroundings of the patient. It is a reproach to our civilisation, with its boasted eleemosynary and philanthropic principles, that the proportion of recoveries is greater in those blessed with ample means than in the poor. And it is a crude and unpleasant truth that the cure of tuberculosis is largely a matter of means.

Treatment

In attacking tuberculosis of bones and joints we are more fortunate than in dealing with pulmonary tuberculosis. There, for example, we can only employ general measures, whereas in osseous and articular tuberculosis we have at our command remedies both general and local.

General Treatment.—A most important point which is now being recognised is that all such cases are not suitable for treatment in the wards of hospitals in cities and large towns.[1] They do not make complete recoveries, and in tuberculosis "half-cures are no cures at all." In fact, after a temporary improvement due to rest and good food, they often deteriorate steadily. Further, they are a danger to other hospital patients, and if not entirely cured, they are a source of infection to others on their return home. What is required is treatment in the "open-air," as in phthisis. Whilst the well-to-do can command this under the best circumstances, in sunshiny

[1] Cf. A. H. Tubby, "The Urban Hospital Treatment of External or Surgical Tuberculosis," *Brit. Med. Jour.*, Feb. 21, 1903; also, "Is the Urban Hospital Treatment of External or Surgical Tuberculosis Justifiable?" *The Practitioner*, Sept. 1903; also *Tuberculous Cripples*, by A. H. Tubby; Kelynack, *Tuberculosis in Infancy and Childhood*, p. 188, London, 1908, Baillière & Co.

sea-side or dry country places, the children of the poor are unable to do so. For them we need many properly equipped institutions where the climatic conditions and surroundings are suitable,[1] where there are no restrictions as to age, duration of stay, and no red-tape regulations about subscribers' letters. In effect, the claim of such sufferers should be this fact, that they are the victims of a disease which is generally curable, although the cure is tedious. One completely cured case is worth very many partially cured or patched-up cases. The time must and will come when every general and children's hospital will have its home of rest away from the city, where only tuberculous cases are dealt with on the lines indicated above. And it will also be the business of the community to provide retreats for incurable patients.

The details of the open-air treatment of bone and joint tuberculosis are precisely similar to the well-known methods used in treating phthisis.

Drugs.—They are of little, if any direct value, except perhaps cod-liver oil. Preparations of iron and tonics in general are useful, while, if patients can tolerate creasote alone or with cod-liver oil, some good seems to be effected.

Local Treatment.—Rest, fixation, and relief of muscular spasm are the main points. The methods by which they can be obtained will be described in dealing with individual joints.

Local Applications.—Undoubtedly the best of them is iodoform. It is used in the form of an emulsion with glycerine, about 10 cc. of a 10 per cent solution being injected into a joint. Some patients are susceptible to iodoform, and poisoning and death have resulted.[2] It is best to begin with 5 cc. of the emulsion, and repeat the injection several times at intervals of three weeks. In many instances, especially of early tuberculosis, it seems that the healing process has been hastened, while the patient's general condition has improved. Iodoform (5-10 per cent) dissolved in ether is often used.[3]

For the treatment of bones and abscess cavities, Harold Stiles

[1] A beginning on sound lines has been made with the Liverpool County Hospital and the Lord Mayor Treloar Home and College at Alton. And the good work done by older institutions, such as the Sevenoaks Hospital for Hip Disease, the Yarrow Home, the Royal Sea Bathing Infirmary, and many others, deserves full recognition.

[2] The toxic effects are less if crystalline iodoform is used in preference to the powdered drug.

[3] Two to five cc. of the solution are injected at first, and if the patient tolerates it, 10 cc. may be given. Iodoform-ether is said to have sclerosing properties. An oily solution of iodoform is of value, if the pus is caseous.—J. Calvé and H. J. Gauvain, "Technique of Aspiration," *Lancet*, March 5, 1910.

uses a sublimated iodoform-bismuth paste, composed of iodoform 1 pt., subnitrate of bismuth 2 pts., stored in a solution of 1 in 1000 perchloride of mercury. The paste is made of varying consistency, according as to whether it is intended to rub out a cavity or to pack it. A useful injection into tuberculous abscess cavities is an emulsion made of menthol ʒj, dissolved in alcohol ℥j, and then mixed with glycerine Oj. Ménard uses a thymol-camphor injection for his spinal cases.[1] Phelps advocated pure liquid carbolic acid in the treatment of tuberculous abscesses and sinuses. It is allowed to remain in for a minute, and is neutralised by frequent washing out with alcohol, and the part is then cleansed with normal salt solution. Chloride of zinc in a 10 per cent solution, tincture of iodine in iodide of potassium, have also been used with variable results for tuberculous ulceration.

Bismuth Injections of Sinuses and of Bone Cavities.—Ridlon and Wallace Blanchard[2] have described this mode of treatment. "On January 15, 1908, Dr. Emil G. Beck, of Chicago, reported that whilst using bismuth-vaseline paste for the purpose of obtaining a clearly outlined skiagram of the track a sinus pursued, he accidentally discovered that the paste was a cure." And on February 3, 1908, Ridlon and Blanchard commenced trial of the method. Two formulæ were employed—

No. 1. For Diagnosis

℞	Bismuthi-subnitratis . .	1 part
	Vaselin	2 parts

Mix while boiling.

No. 2. For Treatment

℞	Bismuthi-subnitratis . .	6 parts
	White Wax . . .	1 part
	Soft Paraffin . . .	1 part
	Vaselin	12 parts

Mix while boiling.

[1] Ménard says: "For over two years we have used 'le thymol camphré.'" *The Extra Pharmacopœia*, 1906, states: "The two solids, Thymol $C_6H_3(CH_3)(OH)(C_3H_7)$ and Camphor $C_{10}H_{16}O$, are rubbed together in equal parts and form an oily liquid." Ménard, however, uses thymol 1 part and camphor 2 parts, and writes thus: "After a great number of injections, in which the quantity of liquid used varied from 5 to 40 grammes, we have never observed a case of intoxication." He and others say that naphthol-camphor causes intoxication, and salol-camphor is too unstable. Thymol-camphor injections are particularly indicated, if the pus is caseous (J. Calvé and H. J. Gauvain, *loc. sup. cit.*, p. 23.

[2] *Amer. Jour. Orth. Surg.* vol. vi. No. 1, Aug. 1908, p. 13, "A New Treatment for Old Tuberculous Sinuses."

In most of the cases mixture No. 1 [1] was used for diagnosis, and it was evacuated within twenty-four hours. Then mixture No. 2 was injected into the sinus until it would hold no more without painful distension. "The injections are made with the bismuth paste at a temperature sufficiently above blood-heat to give the paste the consistency of cream. The second formula cools sufficiently in three minutes after injection to produce the consistency of cottage cheese. Cone-point glass syringes are used, of sizes varying from one to eight ounces, with the nozzle placed with gentle pressure in the orifice of the fistula. Every two or three days the fistulæ were injected with an amount of the paste approximately equal to that discharged in the dressings. If none had escaped, no re-injection was made."

How the injection acts is not certain. Beck thinks the bismuth may, after exposure to X-rays, become radio-active and favour the promotion of granulation tissue. Ridlon and Blanchard believe the injection to be merely mechanical in its action. It forces out the pus, fills the sinus so as to prevent ingress of air-carried germs, and, finally, it compresses the unhealthy granulations so that a normal healing process results.

According to Ridlon and Blanchard, of 17 cases of tuberculous sinuses treated in this way 9 were cured in seven to thirty-three days, whilst the remaining 8 were more or less improved at the end of three months.

The method can also be employed after opening tuberculous abscesses, and the amount used is only limited by the capacity of the abscess cavity. A tuberculous abscess is punctured with a narrow bistoury, the pus allowed to escape, and the bismuth is injected. The small size of the puncture prevents the immediate escape of the bismuth paste, which now becomes "a most effective plug against outside infection." Sometimes both sinuses and abscesses will re-open after injection and healing; a little serous fluid and bismuth paste escapes, and then permanent healing follows.

We have tried this method in some half-dozen cases, and have much reason to be satisfied with the results. Undoubtedly healing is quicker in every way, as is seen when contrasted with control cases.

[1] It has been thought that the danger arising from using bismuth subnitrate might be avoided by substituting bismuth carbonate. This is not rendered clear by a perusal of the literature of the subject. It is certain that many surgeons prefer to avoid any preparation of bismuth.

A further report is issued[1] by Ridlon and Blanchard. At the time of writing their experience had extended to over 150 cases. They remark: "Many failures and cases of severe poisoning with at least three deaths have considerably offset the great degree of success which has followed the general adoption of the treatment. We have not had a serious case of bismuth poisoning, but believe great caution should be exercised in the selection of cases, and that the quantity of bismuth paste should be modified to meet the individual conditions." They do not recommend the bismuth paste in cases—"1. When there is progressive destruction or in which the X-ray shows a sequestrum, until the sequestrum has been removed. 2. Amyloid cases are never improved. 3. Its continued use is dangerous, when large distal pus sacs become filled with residuary bismuth. 4. In sinuses of tuberculous bone disease which have existed for less than two or three months. 5. In old tuberculous sinuses with extensive skin destruction and large areas of skin undermined. The greatest degree of success has been attained with the bismuth paste in the treatment of old sinuses of tuberculous joint disease, that have been opened and discharging for from one to five years.

"To avoid danger of bismuth poisoning, and believing that bismuth is not a necessary constituent of a flooding paste, we have adopted the following formula for the treatment of old tuberculous sinus:—

White wax	1 part.
Vaselin	8 parts.

Mix while boiling.

Add for use in badly infected cases $\frac{1}{10}$ to $\frac{1}{2}$ of 1 per cent of powdered iodine at the moment of injection. Immediately after injecting, a thick pad of gauze saturated with alcohol should be bound over the opening. The evaporation of the alcohol cools and hardens the paste and prevents its escape.

"When a cold abscess is opened and the pus discharged, it is necessary to fill the cavity to its full capacity with the bismuth or other paste in order to keep it sterile.

"There is undoubtedly a danger of bismuth poisoning in filling large cavities with bismuth paste. To avoid this danger we have adopted the following formula:—

[1] Ridlon and Wallace Blanchard, *Amer. Jour. Orth. Surg.* vol. vii. No. 1, pp. 34 *et seq.*

White wax	. . . .	3 parts.
Soft paraffin	. . . .	2 parts.
Vaselin	. . . . .	24 parts.

Mix while boiling."

Prescott le Breton has pursued the subject in a paper entitled "Some Experimental Work on Materials for Plugging Sinuses and Bone Cavities."[1] He has used—cacao butter, 7 parts; white wax, 1 part; and iodine flakes, a small amount; also borax, 2 parts; wax, 1 part; and lanolin, 24 parts. Le Breton speaks favourably of these preparations.

Balsam of Peru, 10 per cent, dissolved in castor oil has been recommended by Van Arsdale,[2] and is spoken of favourably. Some years ago cinnamic acid was brought into prominence for the treatment of tuberculous joints by injection. We tried it in ten cases, but derived no satisfaction from its use. P. Rédard details his experiences (*Congress of French Surgeons*, 1909, and *Amer. Jour. Orth. Surg.* vol. vii. No. 4, 1910, p. 509) of injecting phosphate of sodium solution, 1 per cent, 75 cc., and oxygenated water of 12 vols. 25 cc., and recommends its use in tuberculous arthritis.

Scott's ointment (Ung. Hydrarg. Co.), the application of oleate of mercury 10 per cent, and of mercury vasogen, are of use in very early cases. Blistering and the actual cautery have fallen into disfavour except for the relief of pain.

The Treatment of Tuberculous and other Lesions by Bier's Methods

Bier's methods[3] were first employed in the treatment of tuberculous bones and joints, and have gradually been applied to many forms of inflammatory disorders.

There are two forms of hyperæmia, the active or arterial, and the passive or venous.

(*a*) **Active Hyperæmia.**—This is procured by the local application of heat. The apparatus Bier employs is very simple. "It consists of chambers or boxes made of non-resinous wood at

[1] *Amer. Jour. Orth. Surg.* vol. vii. No. 4, May 1910, p. 464.

[2] Whitman, *Orth. Surg.* 2nd ed. p. 205.

[3] On many of the points referred to the writer has obtained much information, and he has quoted extensively from a paper entitled, "Remarks on Bier's Hyperæmia as a Remedy," by Dr. G. Ritchie Thomson of Johannesburg, *Transvaal Med. Jour.*, 1909, Presidential Address. See also Freiberg, *Amer. Jour. Orth. Surg.*, 1904, vol. ii. p. 150, and Luxembourg, *Münch. med. Woch.*, 1904, 10.

least one inch in thickness, and with suitable apertures for the introduction of the part to be treated. The wood is soaked in a soda and silicate solution, to prevent warping and risk of fire. The source of heat is an ordinary gas burner or a large spirit lamp, over which is a metal funnel, both being movable vertically on a chemical retort-stand. The orifice of the funnel is introduced into an angle of an iron tube which enters the chamber near its bottom. The chamber is provided with a flat piece of wood opposite this orifice, so that the hot air, on entering, is evenly distributed, and does not come as a narrow stream into contact with the patient's skin. By raising or lowering the burner, and by further insertion or removal of the funnel from the metal tube, the amount of heat can be regulated; with this object also there are ventilating apertures at the top of the chamber, which carries a thermometer. The main apertures in the chamber are closely packed round the lamp with asbestos and wadding; thick felt or battiste sleeves may be fitted to the apertures, especially if the shoulder or knee-joint is to be treated. The chambers are most conveniently made in two sections, the upper hinged to the lower, the latter having its halves of the apertures provided with hollow wooden pieces on which the limb can rest comfortably. The gas should be lighted before the lamp is introduced. Slight dampness of the skin occurs at a temperature of about 50° C., and free perspiration at 60° C. It increases up to 100° C., and then rather diminishes until the limit of saturation—about 114° C.—is reached. The surface temperature of the limb after removal from the chamber is from one to two degrees higher than before treatment, and remains slightly elevated for about one and a

FIG. 1.—Demonstrating the application of Bier's Elastic Bandage around the Arm, for the production of Passive Hyperæmia. A flannel bandage is placed beneath the rubber bandage for purposes of padding. The distal part of the extremity shows distinct obstructive hyperæmia (Willy-Meyer and Schmieden).

half hours. The duration of treatment is from half an hour to an hour at a time."

(*b*) **Passive Hyperæmia.**—"The first and most widely used method of causing passive hyperæmia is by means of a bandage obstructing the venous outflow (Figs. 1 and 2). Bier uses for the upper limb a thin rubber bandage two and a quarter inches wide, and for the thigh an ordinary Martin's bandage. The thin-walled

FIG. 2.—Showing the manner of application of the Elastic Bandage, according to Bier, in a case of Tuberculous Sinuses of the Elbow-Joint (Willy-Meyer and Schmieden).

veins, the deep as well as the superficial, are compressed, whilst the thick-walled arteries are not at all narrowed, or only to a very slight degree. The requisite degree of pressure will best be recognised from Bier's description of the appearances produced by an elastic bandage applied to his own arm. The bandage is applied round the upper arm only so tightly that it gives rise to no discomfort whatever, and one absolutely forgets its presence if one follows one's ordinary business. The subcutaneous veins on the dorsum of the hand first become distended, and then those on the flexor aspect of the forearm. The skin of the latter gradually acquires a bluish tint; the palm and the extensor surface of the elbow become rose-red. Generally the dorsum of the hand and the fingers are bright red.

"After three hours the skin of the forearm is uniformly blue-red, and prolonged finger-pressure on the dorsum of the hand demonstrates œdema. The pulse is full and strong as compared with the other side. When the temperature of the air is low, the hyperæmic limb feels subjectively colder than its fellow. On finger-pressure at any point the skin becomes pallid, followed by refilling with venous blood on removal of the pressure. In the bluish coloured areas one can by friction induce in the skin active bright arterial redness, which persists for some time. After twenty hours the arm and dorsum of the hand are uniformly œdematous, but the skin of the fingers and palm are still bright red. Sharp friction of any bluish coloured area easily induces a brisk and clear arterial redness.

"If the elastic bandage is applied equally tightly to an inflamed limb, then, according to the degree of the inflammation, the changes are generally much more pronounced. In actual practice we do not employ a degree of stasis greater than that we have previously indicated. An excessive degree of stasis causes a blue-red coloration with rapid œdema, the appearance of bright red spots in the palm, and of vermilion and yellow spots on the dorsum of the hand. The surface temperature becomes lowered and some numbness occurs. This degree of stasis should never be approached. At the most a few vermilion spots may appear after prolonged and thorough use of the elastic bandage.

"Great care must be taken that only a warm stasis is induced, that the bandaged limb never feels subjectively cold, and that the vermilion spots do not appear, and, further, that neither real discomfort nor pain are caused.

"Bier's most modern method is to apply one or two layers of gauze, and over them a rubber bandage, which is kept on for twenty to twenty-two hours daily when we are treating some chronic joint diseases. We must get rid in the interval of the œdema by raising the limb and rubbing it.

"The treatment of tuberculosis varies in many details, and is never continued for more than one to two hours daily, because more pronounced venous stasis is produced, the constriction is such that the subcutaneous veins become greatly distended, the skin uniformly bluish red, and the patient feels pricking sensations; but real discomfort or pain ought never to be caused." It should be added that the peripheral segment of the limb is not bandaged. It is better as a rule to apply the constricting bandage at a distance from the area of disease. In the lower limb hyperæmia is more difficult to produce satisfactorily. Ritchie Thomson finally remarks that, "here success may be achieved by applying the elastic bandage

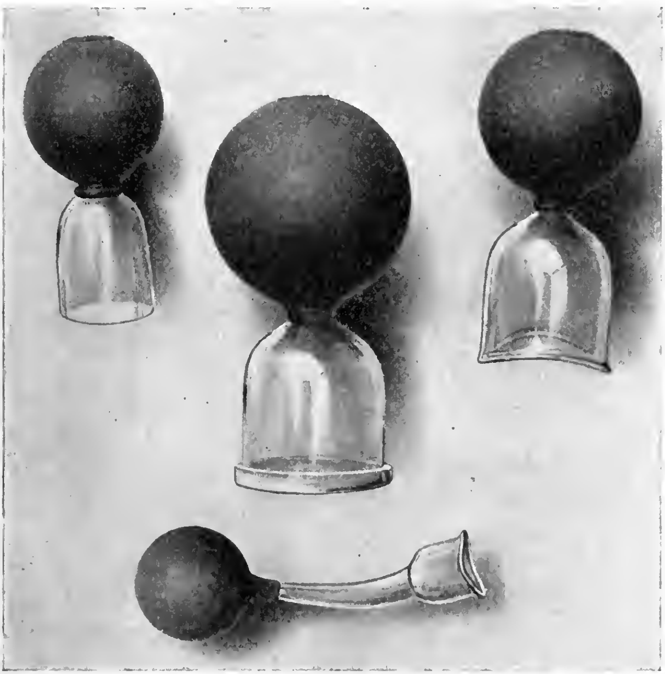

FIG. 3.—These glasses represent the simplest form of Suction-Glasses. They are used in the treatment of Sinuses and small Furuncles by Bier's methods (Willy-Meyer and Schmieden).

so tightly that the limb becomes bloodless. After five minutes the bandage is slackened, so that a marked reactionary hyperæmia results, which is then converted into the desired passive hyperæmia by tightening the bandage to the necessary extent." Bier considers it better in such cases to paint the skin over the affected part with iodine until a marked inflammatory reaction occurs, and then apply the elastic bandage in the ordinary manner.

Hyperæmia by Means of Dry Cupping.—This is obtained by means of cups or suitably shaped glasses, in which a negative pressure of 200 to 400 millimetres of mercury can be produced by means of pumps or rubber-balls with valves (Figs. 3 and 4). As a rule we do not require as much negative pressure as this, and the test is the absence of pain. According to the degree of the vacuum,

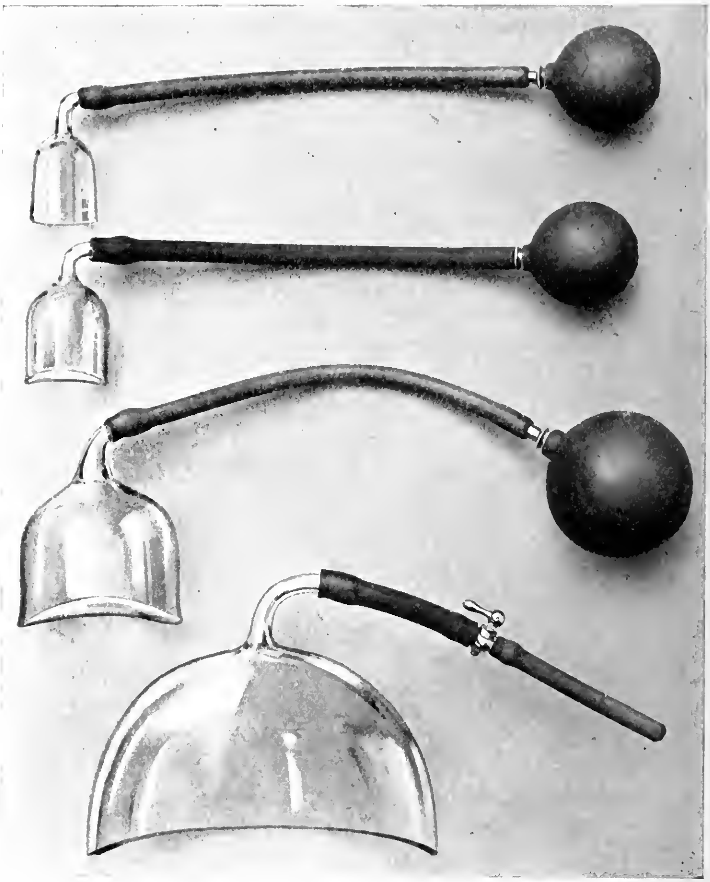

Fig. 4.—Suction-glasses of similar configuration to those in Fig. 3. A rubber tube connects the suction-glass with the bulb. The last named can be detached so as to allow the glass to be sterilised. In one of the rubber tubes a three-way stop-cock is inserted. These cups are used for treating Furuncles of large dimensions (Willy-Meyer and Schmieden).

the hyperæmia varies from an active one with slight negative pressure to a pronounced one with great negative pressure. The cups are applied for five minutes at a time at three-minute intervals, the whole treatment occupying forty-five minutes. They are mostly used for such conditions as boils and carbuncles, abscesses and sinuses; and for these forms of septic troubles small incisions or punctures are made in the areas to which the cups are applied. In the treatment of tuberculous affections a lower vacuum is used than in acute inflammatory affections.

In the treatment of stiff joints, Bier employs large suction glasses with chambers, and obtains a greater negative pressure. The suction glasses are of various shapes to fit different joints; and the method is of value in quiescent tuberculous joints and in those stiffened from chronic rheumatism or from trauma.

General Effects of Hyperæmia.—The first is relief of pain, and passive hyperæmia is more beneficial in the gonorrhœal, acute rheumatic, and phlegmonous inflammation, and in tuberculous arthritis.[1] Active hyperæmia is useful in neuralgia.

It is claimed that the most important effect of hyperæmia is an attenuating one; and, according to Adami, Bier's method of hyperæmia brings in through the afferent vessels further supplies of leucocytes, precipitins, lysins, and opsonins on the one hand, and on the other hand causes a rapid removal of the dead bacteria from the field of action. A full discussion on these points, however, is not within the limits of this volume, although the question at issue will be referred to presently.

Another action of hyperæmia is its effect on absorption. It widely promotes it; and it has been shown that after artificial ischæmia produced by an Esmarch's bandage, absorption is greatly hastened by the reactionary hyperæmia which takes place on removal of the bandage.

A further result of the hyperæmia is, according to Bier, a dissolving influence, by which coagulation products and exudations are liquefied prior to being absorbed. Thus nodes on tendons and some solid exudations into joints have repeatedly disappeared after the induction of local hyperæmia.

In tuberculous affections, particularly at an early stage, Bier's methods are of undoubted value, more particularly at the wrist,

[1] Mr. Maynard Smith, *Brit. Med. Jour.* vol. ii., 1909, "The Inoculation Treatment of Tuberculous Arthritis," gives his conclusions, derived from observations on a number of cases, as to the degree of assistance the surgeon may obtain from the vaccine therapist and the opsonist; also as to what help, if any, the surgeon can give to the vaccine therapist. For the latter purpose, Bier's methods are employed when a diagnosis is needed. "The principle of these methods depends on the production of an auto-inoculation of the patient from the lesion under examination, and by subsequent estimation of the tuberculo-opsonic index at intervals of a few hours, to ascertain whether that fluctuation (in the index) has taken place, which would have been expected, had a tuberculous auto-inoculation been produced."

knee, and ankle, and in the various forms of tuberculous dactylitis. They should be used perseveringly for several weeks or months. When pus has formed it should be evacuated, and the method persevered with somewhat more extensively; and evidence is accumulating to show that the shrinking of abscess cavities and diminution in the production of pus is hastened thereby, whilst sinuses undoubtedly heal more quickly.

We may now return to the discussion of other explanations of the good results thus obtained. We have already mentioned that the fluids in the centre of a localised tuberculoma have a lower opsonic index than the patient's blood. In a tuberculous abscess the pus may be actually devoid of opsonin. Tuberculous conditions are largely avascular, and it is of little use to the patient to have a high opsonic index if the plasma, rich in opsonin, is unable to come into contact with the actual disease. In von Bier's method the part is supplied with a copious supply of lymph rich in opsonin, or at all events as rich as the general plasma, and relatively to the centre of the tuberculous area the index is certainly high. Further, this lymph is under pressure, and transudes the part thoroughly. That this is probably the rationale is shown by Sir A. E. Wright in discussing a somewhat reverse process. The relief of pressure in a tuberculous collection, *e.g.* abscess, empyema, diffuse peritonitis, by operation, allows the lymph, with whatever bacteriotropic material it contains, to bathe the diseased tissues, with excellent results. In tuberculous sinuses Wright most ingeniously applies these principles. Free access of lymph is prevented by fibrinous deposits. He therefore introduces into the sinus a solution of ·5 per cent citrate of soda, to prevent coagulation, and 5 per cent sodium chloride to set up osmosis and a free outward flow of lymph. It is certain that in a great many surgical cases the complete removal of all infected material is an impossibility, yet patients very frequently do perfectly well. The explanation is now obvious. The part is flooded with lymph, a process which can be aided by the administration of sodium citrate in 60-grain doses every three hours, so as to diminish the coagulability of the blood and prevent re-blocking of the channels.

The indications are then to soak well the diseased area with lymph with a high opsonic index to the tubercle bacillus. And this leads up to consideration of how the opsonic index, usually low in surgical tuberculosis, can be raised.

Sir A. E. Wright has shown, as we have stated in dealing with diagnosis, that *the injection into a tuberculous subject of a minute dose of an appropriate tuberculin* produces an immediate and temporary lowering of the opsonic index, or negative phase, followed by a more or less prolonged raising of the same, or positive phase; and that it is possible, by watching the index, so to time the injections as to, in a measure, secure a high positive effect. In pulmonary tuberculosis, owing to the vascularity of the parts, the fluctuating conditions, and the inability to attain local rest, auto-inoculation is irregular, and the response, as indicated by the fluctuating index, correspondingly so. This makes vaccine therapy difficult. But in surgical tuberculosis the conditions are much more favourable; the part can be put at rest, and auto-inoculation regularised, leaving the field free for the careful experimental production of a more constant high positive phase. There is one difficulty, however—that is, the selection of a suitable vaccine. Is the organism present the human or the bovine form? Are we to use a tuberculin of human or bovine origin? One, and from a scientific point of view the best, way out of the difficulty is to prepare an autogenous vaccine. Preparation of a vaccine entails first inoculation of a guinea-pig, then culture and standardisation of the organism, taking altogether three months or more. And not infrequently the attempt at culture is unsuccessful. Still, it is often advisable that the trial should be made. Meanwhile one can proceed with stock tuberculin of human origin, of bovine origin, or, as R. W. Allen suggests and practises, a mixture of both may be used.[1] For the treatment of bones and joints Cobbet's work on the Royal Commission indicates that tuberculin of human origin is appropriate, but glandular tuberculosis appears to be as often bovine as human in type.

We cannot discuss here the composition and properties of the various stock tuberculins. Those most used therapeutically are the new tuberculins T.R. of both human and bovine origin.[2]

[1] Emery, *op. sup. cit.* p. 384: "Tuberculin is also prepared from bovine tubercle (*Perlsucht*) bacilli; and its use, when mixed with the human form (as recommended by Allen) appears rational and quite worthy of trial. The majority of cases of human tuberculosis are due to bacilli of the human type; but at the worst, the material derived from the bovine bacilli will be inert and do no harm."

[2] There are many to choose from, old tuberculin T.R.; B.E., bovine tuberculin, antiphthisin, but T.R. and B.E. are in general use (Emery). As is well known, the late Professor Robert Koch continued to work up to the time of his death with the products of the tubercle bacillus, in order to improve the tuberculous preparations, and obtain a method of treatment which would satisfy all requirements. Jochmann (*Deutsch. med. Woch.*, May 26, 1910, and *Epitome Brit.*

As to results, R. W. Allen says:—"For a case of early joint-disease splints, rest, Bier's congestion, and tuberculin will probably suffice to effect cure. Should the disease be advanced, and the surgeon decide upon scraping or excision, a preliminary raising of the index by means of tuberculin will minimise the risk of dissemination, and a continuation of such treatment after the operation will expedite the cure. It may, however, be noted that cases of this kind, so advanced that even amputation was advocated, have cleared up in such a marvellous manner under tuberculin and the usual therapeutic measures, that no case need be considered hopeless until such measures have received trial. In my own experience these cases do extremely well, especially if treatment be simultaneously directed against any secondary infection; the cases which do not do well are those in which other parts are also affected, where there is marked wasting or signs of lardaceous disease, or where secondary infections cannot be controlled owing to neglect on the part of the patient."

Secondary infections in the case of tuberculous disease of bones and joints with sinus formation are almost the rule—staphylococci and streptococci being present. The necessary treatment for them is the use, primarily, of a corresponding vaccine, that is, a dose of 250 to 500 million of the organisms (killed, of course) is administered; and the index to this organism taken, if considered necessary.

We have gone very little into detail in these matters, since it is clear that we must depend upon the laboratory expert for treatment conducted on the above lines. Western, Raw, Turton, Painter, and others record cases in which the measure of success was such that the conscientious surgeon of the future will be forced to follow these lines in part. It is to be hoped, however, in view of the limited application of such an essentially costly procedure, that we may before long be provided with a scheme by which the vaccines can be safely administered, guided by clinical symptoms largely. At present this is being widely practised—that is to say,

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Med. Jour. vol. ii., 1910, p. 19) has attempted to form a comprehensive idea of the relative values of Koch's material. He states that in his opinion it is better to begin with A.T. (old tuberculin), injecting 1 mg. and increasing the dose gradually, without producing a marked febrile reaction, until 1 gram is reached. He uses tuberculin B.E. at a later date. B.E. is a glycerine sodium-chloride emulsion. Jochmann gives ·001 mg. of B.E. to begin with, and increases the dose gradually to 10 mg. We may add that 1 gram of A.T. seems an enormous dose; possibly there may be a misprint in the quantity. Béraneck's tuberculin, its preparation, dosage, and effects, are described in Appendix II. at the end of this volume.

tuberculin is used, guided by clinical experience only; but such a procedure must be largely working in the dark. And in view of the complexity of the problem, the general low index in surgical tuberculosis, and the limited surgical experience of the "clinical method" up to the present, the author's opinion is that, paradoxical as it may seem, whilst the clinical method[1] may be safe in the hands of the expert used to opsonic work, it is unwise for the non-expert to attempt to forego the guide afforded by the determination of the index.

The writer's friend, Dr. Butler Harris, an authority on the questions at issue, has favoured him with the results of his clinical experience and observations in the following paragraphs:—

"The discovery of opsonins has led to further investigation of tuberculous infections of bone and joints.

"The reason for the usual surgical procedure of clearing out completely bone abscesses, and affording free drainage, is now more clearly explained. The fluids of an abscess cavity, and its immediate vicinity, are proved to contain little or no anti-bacterial substances, as measured by the opsonic index, compared with the amount in the circulating blood.

"Free excision and drainage, therefore, afford a flooding of the tissues in this area of low bacteriotropic pressure with serum rich in protective materials, infinitely more destructive of bacterial life in tissue than any external antiseptic.

"The mere act of operation, at the moment, however, does more than this. Actual auto-inoculation by the introduction of dead bacilli into the system takes place; and if the opsonic index be taken before operation, and a few hours later, it is invariably found that a decided negative phase occurs owing to this absorption or rubbing in of dead and possibly of living micro-organisms. A day or so later the opsonic index rises very appreciably, inversely as the temperature, which rises after operation, falls. Improvement, therefore, is not merely due to the removal of infecting and toxic substances, but also to the absorption of materials whose association with surrounding healthy tissues actually produces anti-bacterial bodies.

[1] "It must be pointed out that the therapeutic necessity for the opsonic control depends on the acceptance of the fact that tuberculin asserts its beneficial influence by causing an increase in the amount of opsonins present in the blood. This view is not, however, entirely accepted. Admitting that the immunity is due to anti-bodies, these may be bactericidal substances or anti-bodies; and we have no reason whatever for thinking that the opsonic index affords any clue to the amount of these substances found." Emery, "Immunity," *op. sup. cit.* p. 387.

"It follows that in the treatment of tuberculous bone and joint lesions which ultimately require surgical aid, it is helpful to ascertain the general protective power of the body; and if low, and not fluctuating, to increase it by a limited series of inoculations. The after-success is more marked the greater the protective power of the serum which invades the fresh wound immediately after the operation. As regards the after-treatment, if the opsonic index again falls after the rise produced by the auto-inoculation (due to the operation), it is wise to continue the inoculations. It is obvious that it is unscientific to inoculate after operation until the disturbance which has been so produced has settled down.

"Old tuberculous lesions, *e.g.* sinuses leading up from infected bone or joints, appear to do best if cleared out before inoculation is begun. Cases which have needed repeated interference often heal up on inoculation. It appears that tuberculous bone lesions respond more readily to inoculation than lupus, which is very unsatisfactory.

"The influence of change of climate—preferably to the East Coast—is in some cases very marked. It sometimes happens that a patient fails to respond to inoculation after a while; and an increased dose only tends to produce a negative phase. Change to the seaside, particularly in hip cases in the young, as is well known, is essential; and it is interesting to note that response to inoculation which had been lost at home returns under the more bracing conditions of sea air.

"There are, however, early states of tuberculous infection of bone, such as early caries of spine, hip, knee, etc., which experience has shown are cured automatically if the infected area is kept absolutely at rest. Hitherto the presence of fever has been taken as one of the indications of active mischief. Wright has shown that in the case of a tuberculous hip, the pressure of the head of the bone in the acetabulum produces a pestle and mortar action, whereby toxins and bacilli are rubbed into the surrounding tissues. The nett result is one of constant auto-inoculation with excessive doses, and a consequent continuous lowering of the protective materials in the circulation. Absolute rest and extension of the limb minimises this action, resulting in a rise of the opsonic index. It is, however, found that the general resisting power of such cases is, when resting, usually subnormal; and great benefit accrues by the employment of minimal doses of tuberculin. There is usually much more rapid improvement when this treatment is superadded to the usual surgical procedure; but, as has been indicated above, this must not be commenced until all the effects of the operation have worn off.

"In the subsequent stages in the treatment of these cases, estimations of the opsonic index, and by X-ray observations, will enable the surgeon to judge accurately whether the last step has been taken prematurely. The index will fluctuate when variations in temperature are very slight, indicating that the local infection is not yet extinct. For diagnostic purposes a series of opsonic indices will afford evidence as regards the presence of the tubercle bacillus in the preliminary investigations of what is clinically a doubtful case.

"As a help in the differential diagnosis of the infecting organism in a bone or joint lesion, this method is of positive value.

"*Immunisation.*—Sufficient time has not yet elapsed to obtain statistics as to the permanency of immunisation obtained by rest and tuberculin inoculations in the early cases of bone infection. It must, however, be remembered that the tubercle bacillus in the human host is particularly resistant when once it has gained a foothold, and that perhaps even for several years after an apparent cure has been effected, it is advisable from time to time to give tuberculin inoculations. A case of early hip-disease under the writer's (Dr. Butler Harris) care forcibly illustrates this dictum.

CASE 1.—"A lad, aged four years, developed signs of morbus coxæ. He was treated in the usual way with rest and extension, and was apparently cured. Seventeen years later, the disease again manifested itself in the same situation and was confirmed by X-rays. He was put to rest with extension and given inoculations for eighteen months, as his opsonic index whilst resting was persistently low. A second examination by the X-ray showed the lesion in the head of the femur to be healed.

"Nine months later, after leading an ordinary but not arduous country life, but without inoculation, pain and stiffness in the joint returned. A skiagram showed on this occasion, not a lesion in the former situation in the head of the bone outside the articular surface, but a series of small indentations on the articular surface itself, and a rather larger one on the acetabulum. The opsonic index was found to be variable in the twenty-four hours, although there was no rise of temperature at night. The régime of rest, extension, and regular inoculations was returned to, so that within three months all trace of pain and limitation of movement disappeared, and for the last year he has been knocking about in South Africa. He has, however, been inoculated about once a month as a precautionary measure."

Another case illustrates the return of tuberculous infection in a fresh site:—

Case 2.—"A child aged four years developed tuberculous glands. The opsonic index was persistently low. Five inoculations were given until the index stood more or less constantly at ·9. One large gland which remained was removed intact, and was found to contain a large caseating abscess. The wound healed by first intention, and remained healed. The child apparently kept well, until some two years later he complained of stiffness and pain on walking. There were the usual signs of tuberculous infection of the hip-joint. Rest, extension, and regular inoculations were instituted. It was found that if the inoculations were discontinued the child flagged, and later they ceased to be able to raise the opsonic index until he was sent away permanently to the seaside. After twenty months he was allowed to walk, as flexion was perfect, and the X-rays showed the joint to be soundly healed. Shortly after getting on his feet he fell and broke the other femur. This, however, mended perfectly. There has been no return of the tuberculous infection apparent anywhere, but it has been repeatedly noticed that a cold or a sore throat is usually accompanied by a lowering of his tuberculo-opsonic index; and it seems not unreasonable to infer that his inoculations should be continued at monthly intervals for the next two or three years. It is now, May 1911, two years since he broke his sound femur, and he is gradually getting more robust."

"Wright in his *Studies on Immunisation* has published a series of cases from the Inoculation Department of St. Mary's Hospital, illustrating some of the diagnostic and therapeutic problems that can be solved by recourse to the auto-inoculation test and by consideration of its event.

"Fifty cases of various types are recorded; of these 21 are infections of bone, and 20 tuberculous infection of bone. The usual result of active exercise or massage, according to Wright's observations, is primarily within an hour to produce a sharp drop of the opsonic index by auto-inoculation. Within twelve hours the original level is reached if the auto-inoculation is not excessive; after twenty-four hours the apex of the curve is not infrequently reached. There may, however, be an actual rise of the opsonic index shortly after exertion, such as Inman has shown takes place in phthisis when the appropriate amount of exercise is taken.

"This immediate gain often occurs when minimal doses of tuberculin are injected; and it is reasonable to infer that the auto-inoculation which produces a similar effect is also a minimal one. A study, therefore, of the opsonic index provides an indication as to how far exercise or massage may be remedial or harmful in the management of a tuberculous bone lesion. As an aid to differential diagnosis in the case of an infected joint, a series of opsonic estimations of the staphylococcus, gonococcus, pneumococcus, and tubercle bacillus, before and after exercise, massage, or the application of a Bier's bandage, will afford valuable evidence as to the nature of the infection.

"Synovial fluid aspirated from an infected joint will invariably yield a very low opsonic index of the infecting organism."

Vaccine therapy, as applicable to the various forms of practice, was exhaustively discussed at the Congress of American Physicians and Surgeons, 1910. Dr. C. F. Painter, in a long and thoughtful paper[1] entitled "Vaccine Therapy in the Management of Arthritis," went into the whole question, dealing with the following types—tuberculous, gonorrhœal, chronic infective, and syphilitic. Of tuberculous infections he says: "It seems to be generally conceded that tuberculosis is a local disease, perhaps more than any other with which we have dealings. . . . The chief evidence that the lesions are local, and that immunity is therefore probably local, is that in the same person and the same region of the body healing and advancing lesions may be found. What the process of immunisation is, is not known. . . . Not much is known about the tuberculo-opsonins, but some authorities have pointed out that a high tuberculo-opsonic index does not necessarily mean that the lesion is under control; on the contrary, this test is very uncertain, and it has often been noted that advancing or chronic tuberculous lesions have been accompanied by high indices. . . . Attempts to determine the proper time to interfere surgically in a tuberculous bone-lesion, for example, by means of estimating the opsonic index, are futile. . . . It was with patients who had marked infections, and to whom, in combination with their tuberculin, was given a vaccine, made from the contaminating infection, that my only favourable results of vaccine treatment in tuberculous lesions have been obtained. The constitutional immunisation with Marmorek's serum appeals to me much more than does the vaccine treatment."

In conclusion, Painter remarks: "As regards tuberculous joint infections, there does not seem as yet to be any well-established theoretical ground for a belief that vaccination after infection could play a curative rôle. Practically there is very little evidence that it ever does." Also, he adds, "there is very little reason for thinking that vaccination and serum-therapy are, at present, even adjuvants to our therapeutic measures, with the probable exception of Marmorek's serum in the treatment of tuberculous arthritis."

[1] *Trans. Amer. Cong. Phys. and Surg.*, 1910, vol. viii. pp. 344-364.

Dr. John Ridlon at the same Congress gave his experiences on "The Value of Tuberculin in the Treatment of Tuberculous Joint Diseases." He says: "The general symptoms of the joint disease did not disappear more rapidly as the result of the vaccine treatment. In summing up my observations of the value of vaccine therapy in the treatment of tuberculous joint disease by Wright's opsonic method, it seems to me that the best I can say for it is that, in careful hands, it is a harmless method of treatment; that in the vast majority of cases it is of no appreciable value." Dr. Ridlon adds: "If my final word be asked, it is this: Tuberculin administered by the clinical method in harmless doses is useless; administered in larger doses, it is both dangerous and harmful."

Marmorek's Serum.—In addition to Dr. C. F. Painter's opinion given above as to the value of this serum, Glaessner in his article[1] states that of 70 observers, only 11 had found the method unavailing; and 938 cases are quoted, in which 833 obtained positive or good results, and 105 negative. Injections are given either subcutaneously, not more than 5 cc., or by the rectum, not more than 10 cc., more usually the latter. The injections are given daily for eight to ten days, followed by an intermission of ten to fourteen days. Sikemeier[2] treated 17 cases with the serum, and he considers his results to have been favourable in 12.

X-Rays.—In some forms of tuberculous affection, particularly in the early stages and before pus has formed or caseation has occurred, judicious application of the X-rays has appeared to effect a marked improvement.

Operative Measures in the Treatment of Bone and Joint Tuberculosis

Opinions as to the comparative values of conservative and operative measures have for long been somewhat at variance; some surgeons are almost entirely conservative, and others are aggressive, according to the type of case seen by them. But we now begin to see, "as in a glass darkly," it is true, why we should withhold our hands at one stage or in one case, and when we should interfere at once in others. Improved methods of microscopical examination, the collating of carefully collected data, the advent of the Röntgen-ray method of examination, and the light thrown upon tissue inter-

[1] *Deutsch. med. Woch.*, 1909, Nr. 17, p. 753.
[2] *Centralbl. f. Chir. u. mech. Orth.*, Feb. 1910, p. 62.

reaction by Wright and his co-workers, have helped to clear away some of the obscurity surrounding tuberculosis. We can here merely allude to some leading points, for we speak in detail later on of the treatment of individual joints and the parts of the skeleton.

In dealing with bone and joint tuberculosis, we are all agreed that conservative treatment should be tried first, but many of us are clearly of opinion that no case should be allowed to run on until synovial and tendon sheaths, subcutaneous tissue and skin, are all involved in one diseased mass. Still less do many of us permit our cases to go on unchecked until mixed or secondary infection occurs. Unhappily this is not the practice of all, and some persist in conservative treatment until the patient's chance of recovery with a useful limb is lost, or even until life is endangered.

In all cases, as a preliminary to treatment, a Röntgen-ray photograph or photographs should be taken. We ascertain thus in the case of the joints whether we are dealing with a primary bone or a primary synovial lesion; and in bone, if the lesion is in the epiphysis or in the juxta-epiphysial region, or both, or if it is in the diaphysial ends of the bones. We know, too, whether there is present a localised or diffuse lesion, and our course of procedure is determined. According to Mr. Harold Stiles,[1] if the lesion is primarily synovial, we may try for a few weeks conservative treatment, but if a bony lesion exists we should operate at once. And with this opinion we concur in the main.

It is also desirable to ascertain the opsonic index and the resistance of the patient, or otherwise, to the virus. Further, by ascertaining the times of high tide and low tide, or positive and negative phases, we can choose our date for operation with advantage to our patient. All operations on tuberculous bones, joints, and cold abscesses must be strictly aseptic, so as to avoid the great risk to the patient of producing mixed infection—a complication of incalculable harm. The use of an Esmarch's bandage is not desirable because of the oozing into the cavities and tissues which follows, and the necessity of using a drain. In fact, we may say at once that drainage after operations on tuberculous joints and bones is not necessary, unless we fear oozing, after the use of an Esmarch's bandage, or because we have been unable to arrest all capillary hæmorrhage; or if no strong antiseptic has been used to mop out the cavity; or if mixed infection and sinus formation

[1] *Operative Surgery*, Burghard, vol. ii. p. 64.

are absent. The quicker the skin heals over a tuberculous area, the more likely is the operation to be successful.

We speak later of para-articular tuberculosis, and every means should be employed to ascertain its presence at as early a date as possible, for thereby joints are frequently saved and disease arrested. It is equally important to recognise localised intra-articular disease. The writer could quote several instructive cases where a well-defined area of infection of the synovial membrane of the knee has been excised, and a sound useful joint has been secured for the patient. Nevertheless the operator should beware of the danger of general infection of the joint if he commits the error of cutting into the tuberculous mass. Localised areas of bone-disease are treated by excision.

In the treatment of so persistent an affection as tuberculous arthritis or osteitis, if we decide upon operative measures, it is almost commonplace to say that our measures must be thorough. Yet how often do we see imperfect operations. In attempting to preserve the crucial ligaments of the knee-joint the posterior part of the articular cavity is not examined. Disease may have already crept past the ligaments and invaded the popliteal notch, run along the sheath of the popliteus tendon and into the semi-membranosus bursæ, and is even fungating in the tissues of the popliteal space. We might multiply examples; but, having determined to operate for tuberculosis of bones and joints, every care must be taken with knife, scissors, forceps, gouges, and chisel to eradicate it. No time or pains are to be spared in following it out and removing it. Sinuses are to be excised rather than scraped, all synovial pouches exposed, ligaments sacrificed, tendon sheaths fully opened up and cut away, and tendons themselves removed if their appearance is at all suspicious. Where several synovial sacs are in contiguity, as at the wrist and the foot, we must make sure that they are free from disease before we close the wound. If diseased we deal fearlessly with them. It is only by wide and well-considered procedures, thoroughly carried out, that recurrence of disease and amputation will be prevented.

It is clear, then, that in diffuse tuberculosis complete exposure of the parts is essential, and our efforts are limited only by anatomical considerations. In children, epiphysial lines cannot be removed entirely without dwarfing the limb. Nevertheless, when epiphysial disease tracks through the growing line, and if it does not affect a large portion of the growing area, the epiphysial focus may be gouged out, the proliferating cartilage tunnelled, disease removed from the juxta-epiphysial region, and recovery may follow. On the other hand, diffuse tuberculous diaphysitis, extending through the epiphysial line and involving the joint, may necessitate amputation.

In planning our operation on a joint, we should consider the main function of the part. Thus, at the shoulder, movement is essential. Conservative treatment here causes ankylosis and partial loss of the flexibility of the upper limb; therefore arthrotomy is to be avoided, and early excision is the proper course. At the knee, stability with a straight limb is the great desideratum. Experience has shown that arthrectomy, whilst it may result in extirpation of the disease, yet is often followed by antero-posterior and lateral deformity. Therefore osseous union is to be aimed at, and can only be secured by excision. Moreover, we are not to neglect extraneous means of securing firm osseous union in good position, and should not hesitate to use screws or steel pins.

We have mentioned various local applications to areas from which tuberculous disease has been removed; and, on the whole, the sublimated iodoform bismuth paste, introduced by Stiles, appears to be the best. Still, we wait to be convinced by laboratory experiments of the direct value of any of the various applications.

The patient's convalescence ought to be in the open air, preferably at the seaside, and he should be removed from an urban hospital so soon as the immediate shock and disturbance of the operation has passed away. If there is slowness in healing, the "index" is to be taken, and it will often be found advantageous to hasten the immunisation by appropriate doses of tuberculin.

There is one form of osseous tuberculosis very common in children, which was formerly treated by gouging, scraping, and chiselling the bones, but was too frequently followed by a further outbreak of the disease, or the presence of a persistent infection of the skin. We refer to diaphysitis of a more or less localised type.

My friend Mr. Harold Stiles has grappled with this matter, and has treated it with great success in an entirely original manner. Therefore I quote *in extenso* from his writings:[1]—

"In addition to the primary localised juxta-epiphysial focus so commonly met with, we occasionally have to deal with tuberculosis of the diaphysis in a more diffuse form. It is this form of the disease which we shall specially refer to under the heading of tuberculous osteomyelitis of the diaphysis.

[1] Burghard's *Operative Surgery*, vol. ii. p. 3.

Operations for Primary Tuberculous Osteomyelitis of the Diaphysis

"Primary tuberculous osteomyelitis of the diaphysis may start either in the spongy tissue at some distance from the epiphysial cartilage, or in the medullary canal; and in each situation the disease may present itself as a more or less circumscribed focus; or it may take the progressive infiltrating form originally described by König.

"The circumscribed form of the disease generally occurs as a soft, caseous, avascular focus, surrounded by an advancing zone of active tuberculous tissue, which is of a greyish colour, semi-translucent, and slightly vascular.

"A good radiogram will not only confirm the diagnosis, but in many instances demonstrates quite distinctly the position, size, and shape of the focus, the presence or absence of a sequestrum, and the thickness and extent of the subperiosteal sheath of new bone. It follows, therefore, that a skiagram should always be taken before proceeding to operation, as it shows exactly how much bone requires to be removed.

"**Operation.**—The operative treatment of primary tuberculous osteomyelitis of the diaphysis consists, in the first place, of freely exposing the bone for a distance a little beyond the extent of the disease. The incision is so planned that the dissection occasions the minimum of injury to the soft parts. An intermuscular plane is chosen which avoids injuring more especially the nerve-supply to the muscles. The method usually adopted is, after freely opening up the bone with a chisel, thoroughly to gouge and scrape away the diseased focus. This having been done, either some preparation of iodoform or pure carbolic acid is applied to the wall of the cavity; the latter is then stuffed with iodoform gauze, or filled with Mosetig-Moorhof's iodoform-wax filling.

"While the above method is that which has been invariably employed by those surgeons who have recorded cases of this disease, the writer (Mr. Stiles) is strongly of opinion that such a procedure should be the exception rather than the rule. The early results of such a method of treatment are satisfactory enough, but, unfortunately, it too often happens that the patient sooner or later returns with the scar tuberculous, and the seat of a sinus leading down to further disease in the bone. Such a result is not to be wondered at when we consider that it is almost impossible to remove all the affected area by the gouging process.

"After a few such disappointments, the writer (Mr. Stiles) has, for a number of years past, treated the affection by subperiosteal resection of the diseased part of the diaphysis (Fig. 5). Care is taken to divide the bone well above and below the focus; in short, the disease is dealt with radically as if it were a malignant tumour.

"By the aid of skiagraphy the disease can be diagnosed in its early stage before the focus has perforated the bone. This is the

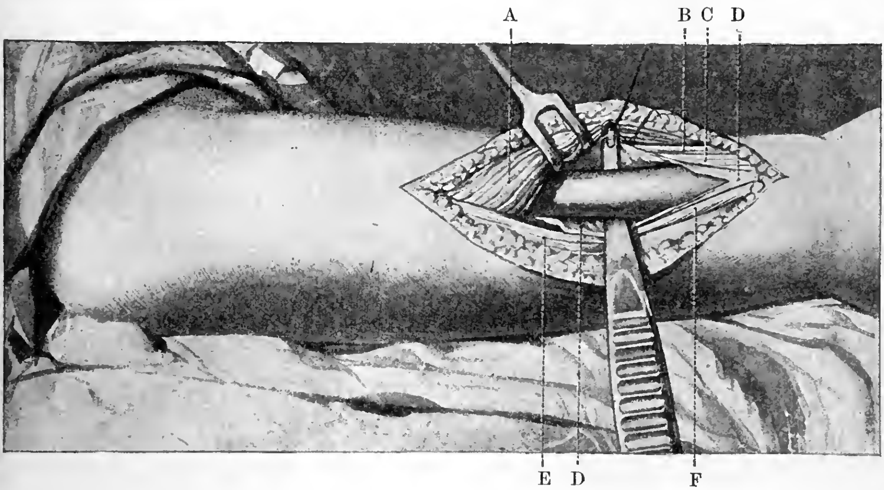


FIG. 5.—To illustrate Harold Stiles' Operation for Tuberculous Diaphysitis. Resection of the lower third of the Diaphysis of the Radius. The extensor pollicis brevis has been retracted upwards and outwards; the extensor minimi (quinti) digiti and extensor pollicis longus have been retracted inwards; the periosteum has been split, and the instrument for passing the wire saw has been introduced between the anterior aspect of the bone and the periosteum.

A extensor pollicis brevis; B, extensor carpi radialis longior; C, extensor carpi radialis brevior; D, D, periosteum; E, extensor minimi digiti; F, extensor pollicis longus (Burghard's *System of Operative Surgery*).

most favourable stage for operation, as the knife can be kept outside the infected area. No iodoform or other antiseptic need be applied to the wound, no stuffing is introduced, and the wound can almost invariably be closed without drainage. The best instrument for dividing the shaft of the bone is a Gigli's saw. This is passed round the shaft, inside the periosteum, which has been previously thoroughly separated all round with a suitable elevator. For introducing the saw behind the bone the writer uses an instrument, which resembles somewhat a broad flattened aneurism needle with an oblique slit leading into a large eye, placed as close as possible to its extremity. After the instrument has been passed behind the bone, and the eye made to project on the opposite side between the bone and the periosteum, the loop at the end of the wire saw is hooked into the eye by means of the slit above mentioned. By withdrawing the instrument the saw is carried behind the bone, the handles are then hooked on, and the bone is sawn across. In young children the bones of the forearm may be snapped across with ordinary bone-forceps, but this instrument leaves a bruised and less even section, with the result that there is often some

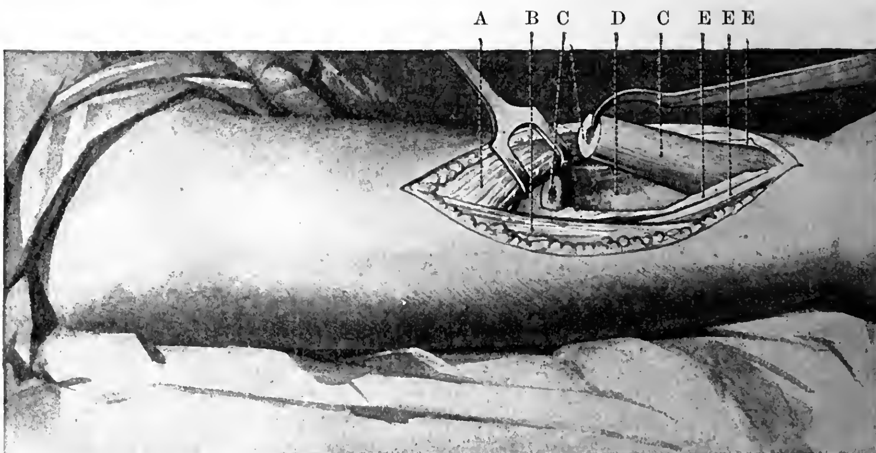


Fig. 6.—Further stage of Resection of the lower third of the Diaphysis of the Radius. The diaphysis has been divided and hooked upwards to enable the periosteum to be separated from the anterior aspect of the bone.

A, extensor pollicis brevis; B, extensor minimi digiti; C, C, radius; D, periosteum; E, E, E, extensor pollicis longus (Harold Stiles in Burghard's *System of Operative Surgery*).

irregularity subsequently where the new bone joins the old. By using Gigli's wire saw, on the other hand, it is often almost impossible, even with a skiagram, to tell, after the new bone has completely developed, where the bone had been divided.

"After the diaphysis has been divided beyond one extremity of the lesion, a strong hook is introduced into the medullary canal, and while the divided end is forcibly dragged upwards, the periosteum is separated from the deep surfaces of the bone until it is freed to a little beyond the opposite limit of the diseased focus. When this level has been reached the saw is again applied and the bone divided. The sawn surfaces of the segment of the bone removed are carefully examined to make sure that they are free from disease; if not, more bone must be removed.

"If the disease has approached close to one end of the diaphysis, or if it has spread along it from a juxta-epiphysial lesion, the diseased segment must be removed right up to the epiphysis. After sawing across the diaphysis, the separation of the diseased portion from the epiphysis is effected by seizing its divided end and wrenching it away from the epiphysis. When this has been done it will be found that the epiphysial cartilage, instead of coming away with the diaphysis, is left firmly attached to the epiphysis. This is what one would expect on anatomical grounds; were it otherwise, the radical operation would be contra-indicated on account of the shortening which would result. As long as the disease has not actually involved the epiphysial cartilage itself, we have found that the above operation does not give rise to any subsequent shortening.

"The bleeding from the periosteal tube seldom amounts to more than a general oozing which soon ceases. Occasionally the main nutrient artery requires to be ligatured. After the bleeding has practically ceased, the periosteal tube is closed with a buried catgut suture; care is taken to suture carefully the two extremities of the incision in the periosteum in such a way as to completely re-cover the sawn stumps of the bone. It is this precaution, combined with the use of the Gigli saw, which enables Nature to effect such a remarkably accurate fusion of the new bone with the old stump. In suturing the periosteum, the writer prefers to use an interrupted rather than a continuous suture, for should the periosteal tube become over-distended with blood the tension is removed by some of the blood escaping between the sutures.

"A few catgut sutures are also employed to stitch the deep fascia, and, in the case of a deep bone such as the radius, the muscles are also stitched, either along with or separately from the periosteal tube. The operation is completed by closing the skin wound with interrupted sutures of silkworm-gut.

"If a sinus already exists at the time of operation it should first of all be well scraped and disinfected with pure carbolic acid. The orifice should be excised by including it in an elliptical incision, which may either form part of the main incision or be independent of it; in the latter case it may be taken advantage of for drainage."

After-treatment.—The after-treatment consists of keeping the limb quiet in a good position for a few weeks, after which it is put up in a suitable splint or in plaster of Paris until the new bone is sufficiently well developed to allow the patient to begin to use the limb. If the disease has not involved the periosteum, the new bone, as already stated, is perfectly re-formed. If, on the other hand, the periosteum has been invaded by the disease, the reproduction is less perfect.

Para-Articular Tuberculosis

In some joints, especially where the epiphysial line is entirely without the limits of the capsule or partially so, a deposit of tubercle may occur in the juxta-epiphysial region, and for a time the focus of disease is entirely extra-articular. Unless the case is recognised early and adequately treated, experience shows that the morbid process extends through the bony substance of the epiphysis, and eventually invades the joint. It is therefore necessary to recognise the existence of this type of the affection. Sometimes pus forms externally to the joint, and then bursts its way through the capsule into the joint.

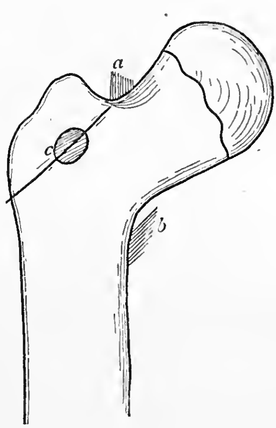


Fig. 7.—A Diagram of the Upper Third of the Femur, illustrating one form of Para-Articular Tuberculosis. *a*, *b*, Attachments of the Capsular Ligament; *c*, Tuberculous Focus at the epiphysial line of the great Trochanter, spreading into the extra-articular bone tissue at the root of the neck.

In joints where the epiphysial line is entirely included within the limits of the synovial membrane, involvement of the epiphysis results in tuberculous arthritis; but in certain instances to be noted presently, the joint escapes for a time, and for a time only. At the lower end of the radius, the lower end of the fibula, and in the epiphysis of the great trochanter (Fig. 7), a para-articular tuberculous abscess may exist for a time without involvement of the joint. The epiphysial lines of the lower end of the radius and the lower end of the fibula are partially within the articular limits, whilst the epiphysis of the great trochanter is, especially at its posterior part, outside the limits of the hip-joint. As to the olecranon, involvement of it usually means disease of the elbow-joint; but Ménard has reported a striking example to the contrary; and according to C. G. Cumston,[1] if the lesion is localised either laterally or on the posterior aspect of the olecranon, the articulation may escape for a time. Epiphysial or juxta-epiphysial tubercle at the lower end of the femur and upper end of the tibia, at the lower epiphysis of the humerus and the head of the radius, is associated very early with invasion of the joint; although Bonnet has described a case of typical tuberculosis limited to the epicondyle.

It therefore follows that some joints are more quickly invaded than others, and there is no doubt that each may become involved in time if the extension of the lesion be not prevented. Tubercle is deposited near the growing line, either in the form of multiple granulations or in foci. It breaks down and forms pus, and this may, as we have stated, either spread through the bony tissue into the articulation, or open on the extra-articular aspect of the bone by a minute orifice, and give rise to a para-articular abscess of considerable size. In many instances the two lines of extension go on simultaneously; in others the para-articular form is predominant, and it is this we wish to consider. Such an abscess is usually situated upon one side of the bone and spreads out along it. It often covers one entire side of the joint, being separated from it only by the capsular ligament and synovial membrane. Sometimes, it is not recognised until it has burrowed its way for a long distance between the muscles and tendons and beneath the aponeuroses. In such instances it is most difficult to discover its connection with the epiphysial region, and prolonged search is often necessary. The focus in the bone is occasionally situated at the point of insertion of one ligament of the joint, and this fact is of clinical significance, because when that particular ligament is drawn upon pain is elicited. Thus, in one case, a boy aged fifteen years complained of pain only when he stood on one foot with it inverted. The painful spot corresponded to the insertion of the long external lateral ligament into the femur, and a local tuberculosis was suspected. An X-ray examination and operation confirmed the finding.

Symptoms of Para-Articular Tuberculosis.—Its onset is insidious and marked only by pain, which is different from and not so continuous as the pain of joint disease. It is well marked after fatigue, and after a period of rest it subsides entirely. The constant

[1] *Albany Med. Annals*, vol. xxvi. No. 8, p. 517, to whose paper on "Extra-Articular Tuberculosis" the author is indebted for some valuable hints.

recurrence of pain at a particular spot should draw attention to the fact that there is probably a small focus of disease there. Such an instance occurred in the case of the wife of a medical man, I was asked to see. She complained constantly of pain over the great trochanter, and there was distinct tenderness, but no fulness. Further, the pain was exaggerated by one movement only of the hip-joint, namely, when the limb was fully adducted; all other movements were quite free. This led to the suspicion that there was a focus of inflammation at the base of the great trochanter at the site of the former growing line. An operation was done, and on cutting down upon the painful spot we found an old caseous focus, which was removed. She made a complete and satisfactory recovery.

In many cases of para-articular tuberculosis muscular atrophy is present, although at the same time the movements of the joint are quite free, except in that one direction where the ligaments or the attachments of muscles pull upon the painful spot. This spot is fixed and unvarying, and whilst other parts around the joint are quite painless, pressure on the diseased area always provokes tenderness. If, in this comparatively early stage, during which it frequently happens that the surgeon's attention is not called to the condition, the part be carefully palpated, a distinct thickening of the bone may be felt. The thickening is hard and non-fluctuating, yet later, evidence of fluctuation is readily obtained. By the time that enlargement of the bone is evident, the lymphatic glands draining the site of the lesion are involved, but as a rule not so much so as when the synovial membrane itself is affected. When the patient consults the surgeon, the pain has become more constant, more marked and definite, but as a rule is still associated with one movement only. Muscular atrophy is readily noted, and the thickening of the joint can be appreciated. The swelling, which is hard and circumscribed, now shows extension, and its outline becomes less definite and softer, probably due to extensive involvement of the soft tissues over the bone. Pressure now gives rise to acute pain; still, so far the neighbouring joint is free from disease, and friction of the surfaces is painless. An X-ray examination shows the tuberculous affection to be extra-articular and clearly defines its outline. The final stage is an involvement of the joint, and occasionally of the medulla.

Prognosis.—In some instances the disease may not advance beyond the early stages, and it may have become encysted. For a long time it may remain dormant, yet in adult life may light up again and give trouble, as in the case quoted above. As a rule, abscess eventually forms, and with that event the danger to the joint is imminent. The most important point in prognosis is early recognition and thorough and radical treatment of the tuberculous deposit.

Diagnosis.—It is most important to decide whether the joint is primarily involved or not. In such a case the natural movements are limited or lost with great rapidity, and nearly all, if not all, of the movements are painful; whilst rapid atrophy of the muscles is characteristic, and the involvement of the lymphatics is more considerable than in the para-articular form. Contractures set in early, and with them there is often a quick deterioration in the patient's general health. In the matter of diagnosis some reliance should be placed upon the patient's history. A localised extra-articular pain in such a patient should give rise to the suspicion that we are dealing with para-articular tuberculosis. Syphilis of the bones may cause pain, which is, however, entirely different in character and position. In specific disease, pain is nocturnal, and is generally in the shaft rather than in the epiphysis. The most valuable aid to diagnosis is radiography. Osteo-sarcomata present difficulties in diagnosis in the early stages, especially if they soften and fluctuate.

Treatment.—At the commencement, absolute rest, immobilisation, and counter-irritation may be of service, but in all except the slighter cases it is imperative to cut down to the bone, evacuate the granulations or pus, and thoroughly scrape the cavity, afterwards treating it with camphorated naphthol, or better still with a solution of chloride of zinc of a strength of 10 per cent. In operating, it is important that the edges of the cavity should be chiselled away until perfectly healthy bone is reached. On three occasions I have prevented involvement of the hip-joint by early recognition of disease at the posterior aspect of the trochanter, and rapid and decisive treatment. In dealing with a large number of bone cases, in the course of exploration for joint disease, all surgeons must have come across this para-articular tuberculosis unexpectedly, and it is often more by chance than otherwise that the joint has been saved. It is evident that we should carefully watch our cases with the objects of making a clear diagnosis and of justifying surgical intervention.

CHAPTER II

TUBERCULOSIS OF THE SPINE

Definition—Ætiology—Incidence of Tuberculosis in the Spine—Pathological Anatomy—Events of the Tuberculous Process—Multiple Foci—Natural Methods of Cure—Signs and Symptoms.

Synonyms—English, *Angular Curvature* (an incorrect expression, and a contradiction in terms), *Tuberculous Spondylitis, Vertebral Tuberculosis, Pott's Disease, Kyphosis, Angular Deformity*; German, *Spondylitis Tuberculosa, Spondyl-Arthritis Tuberculosa, Die Pott'sche Kyphose, Spitzbückel, Winckelförmige Knickung der Wirbelsaüle*; French, *Cyphose, Mal de Pott, Tuberculose Vertébrale.*

Definition.—A morbid process affecting the vertebral column, due to the invasion of tubercle bacilli, and resulting in destructive changes.

Camper and Sévérin directed their attention to the frequent deformity caused by this and other spinal disease, but to Percivall Pott in 1779 must be ascribed the credit of penning a description of it, which remained the most accurate until recent times, although he was unable to differentiate the causes of angular deformity. The discovery of the tubercle bacillus by Robert Koch in 1882 threw a new light upon the whole question of diseases of the bones. We are now able to recognise many varieties of spondylitis, some of which are accompanied by kyphosis and some not. They are the tuberculous, the staphylo- and streptococcic, the typhoid spine, the syphilitic, the rheumatic and gonorrhœal, and that associated with arthritis deformans. The rarer varieties are seen as the result of actinomycosis, tabes dorsalis, and possibly gout. An aortic aneurism erodes the vertebral bodies in some cases, and malignant disease of the spine is sometimes the cause of kyphosis.

However, we have now to consider tuberculous spinal caries.

Ætiology.—*Age.*—The disease is most common during the years of active growth, and notably in early childhood; and frequently follows exanthemata. Statistics differ considerably, but a review of several collections shows that the larger the total of cases the greater is the incidence of the disease on children under five years of age. Mohr[1] found that of 72 cases 29 per cent occurred between the first and fifth years. Drachmann noted that in 161 cases 41 per cent occurred at this period of life, the youngest being eight weeks. Taylor found that, of 376 cases, 60 per cent were under five years. Lannelongue (*Tuberculose vertébralé,* p. 137) has analysed 180 cases in young people under sixteen years of age. Of these, 14 cases were under two years, and 2 were five months old, 1 seven, 1 ten, 1 eleven, and 9 were twelve months. Ninety-one occurred between the second and fifth years, 59 between the fifth and tenth years, and 16 cases from the tenth to the nineteenth year. The common occurrence of the disease so early in life, and the rapid diminution of the number of cases up to the age of nineteen years, should not, however, cause us to overlook the possibility of its onset in middle life and old age. Ménard has seen a recent case at forty-seven and another at fifty-two years of age, but it must not be forgotten that such instances are often due to lighting up of a small focus of tubercle quiescent since childhood. An extensive collection of cases has been made by Waterman and Jaeger.[2] The analysis of 1000 of them showed:—

Age when the disease started.	Males.	Females.
Before 5 years of age	310	290
From 5 to 10 years of age	147	113
,, 10 ,, 15 ,, ,,	12	26
,, 15 ,, 20 ,, ,,	15	13
,, 20 ,, 30 ,, ,,	29	13
Over 30 years of age	22	10
	535	465

The youngest patient was six months, the oldest sixty-nine years of age. Wullstein collected statistics of 1585 cases; 656, or 41 per cent, were under six years of age. He has seen the disease in a man aged seventy-five years, and in a woman aged eighty-seven. It is undoubtedly a rare event in declining years.

[1] Quoted by Bradford and Lovett, *Orthop. Surg.*, New York, 1899, pp. 9 and 10.
[2] *Trans. Amer. Orth. Assoc.* vol. xiv. p. 283.

Prof. Howard Marsh[1] was able to cite only three cases in people over sixty years: one of a man, aged sixty-five, who developed disease of the cervical spine with displacement and projection, followed by an abscess; a second in a patient, aged sixty-four, under Mr. (now Sir H.) Butlin's care; a third, who died at the age of seventy-two years. A post-mortem examination in the last-mentioned case revealed much erosion of the lateral masses of the atlas, the axis, and of the body of the third cervical vertebra, such as occurs in childhood. Sir James Paget spoke of a case in a patient aged fifty-five, and Drachmann says he knew of a case in a man aged seventy-seven. Such cases are probably instances of "Senile Scrofula," the subject of one of Sir James Paget's *Clinical Lectures and Essays.*

Sex does not appear to exercise any particular influence. All statistics agree in that, unlike scoliosis, it is nearly as frequent in girls as in boys. Wullstein states of 6951 cases, 53·29 per cent were males, and 46·71 were females.

The Incidence of Tuberculosis.—The bodies of the vertebræ are composed of spongy enclosed by a thin layer of compact bone. In fact two-thirds to three-quarters of the total spongy bone of the skeleton of a child is found in the spine. Spongy bone is a most favourable cultivation medium for Koch's tubercle bacillus. The spinal column is subject to incessant movement; it has to sustain strong vertical pressure, and even in the recumbent position it is not completely at rest on account of the respiratory movements. The question of traumatism and its influence on the production of vertebral tuberculosis is not worthy of lengthened notice. In some cases the patients definitely date their trouble from a fall or blow; but, in as many instances no satisfactory history of trauma is obtainable, or it is only forthcoming after several leading questions, and the subject is one therefore of little practical interest.[2] In many cases there is a history of tuberculosis in the parents or near relatives. Gibney[3] found a hereditary taint in 76 per cent. In 35 this was traceable to the father, in 38 per cent to the mother, and in 31 per cent to both parents. In 15 per cent, tuberculous disease existed in other children of the family, and in 16 per cent the taint was manifested

[1] *Trans. Amer. Orth. Assoc.* vol. iv. p. 235.

[2] The greater frequency with which the dorso-lumbar region is affected is due to the body-weight and the strain of movements in this area.

[3] Quoted by Bradford and Lovett, *Orth. Surg.* p. 11.

in both parents and children. Waterman and Jaeger's[1] figures differ from Gibney's, and they state that 10 per cent of their cases were born of tuberculous parents. Infantile tuberculosis often becomes manifest after an attack of measles, scarlet fever, or whooping-cough, and no doubt the question of lowered resistance to infection comes in here. The disease is due to tuberculous infection from persons, food, and from dirty surroundings. Whether the disease be primary in the vertebral column or secondary to tuberculous disease elsewhere is difficult to determine. Pulmonary tubercle is nearly always found at the autopsy, and it is not possible to infer with any certainty which lesion was primary. At the Evelina Hospital for Children we have often observed this sequence of events—tuberculous dactylitis, glands, coxitis, or other varieties of arthritis persisting for some months or a year, and then the onset of spinal caries. Very rarely is the reverse order of events met with.

Pathological Anatomy

Localisation.—The region most frequently involved is the lower dorsal.[2] On this point nearly all authors are agreed. Of a series of 100 cases observed by Rédard at the Dispensaire Furtado-Heine, 6 were in the cervical, 5 in the cervico-dorsal, 62 in the dorsal, 5 in the dorso-lumbar, 20 in the lumbar, and 2 in the lumbo-sacral region.[3] R. W. Parker, quoted by Erichsen,[4] gives the following figures: cervical, 9; dorsal, 82; dorso-lumbar, 21; lumbar or lumbo-sacral, 37, out of 149 cases. To be more precise as to the individual vertebræ involved we may perhaps quote further statistics. Waterman and Jaeger[5] found that in 1000 cases the eighth dorsal vertebra was most frequently affected, and the older the patient at the time of onset of disease, the lower its site is. Mohr found that, in adults the twelfth dorsal and first lumbar vertebræ were most frequently the seat of the disease, the second dorsal the next in frequency, then the fourth dorsal and fifth lumbar nearly as often. Our observations incline us to the belief that the vertebræ from the eighth dorsal to the first lumbar are the most frequently attacked.

[1] *Trans. Amer. Orth. Assoc.* vol. xiv., 1901, p. 287.

[2] Cf. Waterman and Jaeger's figures of 1000 cases, *Trans. Amer. Orth. Assoc.* vol. xiv., and compare these with Vulpius' analysis of 6586 cases.

[3] *Traité de chirurgie orthopédique*, p. 232.

[4] *Science and Art of Surg.* 8th ed. vol. ii. p. 421.

[5] *Loc. sup. cit.*

The Part of the Vertebræ first attacked.—This is undoubtedly the bodies, owing to the effects of the superincumbent weight and their cancellous structure. It is stated, although we do not know on whose authority, that quadrupeds do not suffer from spinal caries. A case, however, of spinal caries in a dog was shown by Mr. W. G. Spencer at the Pathological Society, in which two dorsal and four lumbar vertebræ were affected. Sinuses, three on one side and two on the other side of the back, were present.[1]

According to Wullstein,[2] pathological studies have led him to the conviction that the disease may originate in the bodies in three ways—either as, *a*, a central, or, *b*, an epiphysial, or, *c*, a peripheral form. In each case the bacilli are conveyed by the blood-vessels, which in the substance of a vertebral body are arranged in four sets (Fig. 8). Three of these are derived from the posterior spinal artery; and they are distributed, one to the main mass of spongy tissue in the centre and one to each epiphysial plate. Further, the vessels supplying an epiphysial plate communicate through the discs with the plate above or below. This explains the frequency with which adjacent surfaces of the vertebræ are attacked. The fourth set is derived from the intercostal arteries, and supplies the compact and a small portion of the cancellous tissue on the front and sides of the bodies. Tuberculous affection of these last-named arteries gives rise to the peripheral form, which is probably identical with Max David's[3] "Spondylitis Superficialis," and with Ménard's[4] "Periosteal Denudation."

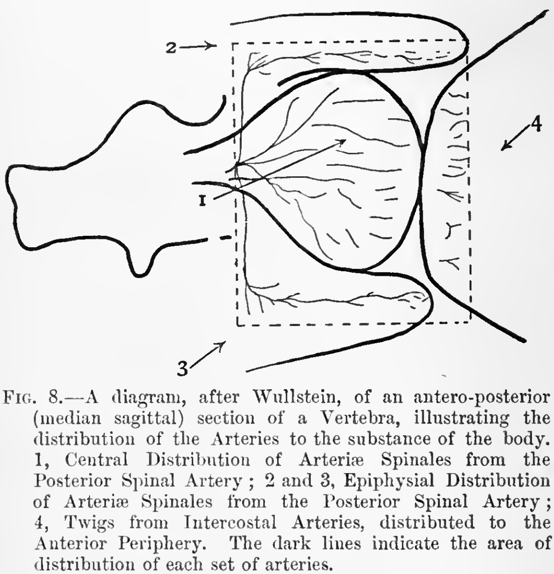


FIG. 8.—A diagram, after Wullstein, of an antero-posterior (median sagittal) section of a Vertebra, illustrating the distribution of the Arteries to the substance of the body. 1, Central Distribution of Arteriæ Spinales from the Posterior Spinal Artery; 2 and 3, Epiphysial Distribution of Arteriæ Spinales from the Posterior Spinal Artery; 4, Twigs from Intercostal Arteries, distributed to the Anterior Periphery. The dark lines indicate the area of distribution of each set of arteries.

[1] *Path. Soc. Trans.*, 1890, vol. xli. p. 341.
[2] Joachimstal's *Chir. orth.* achte Lief.
[3] *Grundriss der orth. Chir.* p. 77.
[4] *Étude pratique sur le mal de Pott.*

a. In the central form (Figs. 9 and 10) the body is gradually hollowed out until it collapses. The arch and processes of the affected vertebra are crowded backwards in the collapse and form a projection or hump. The discs soon become invaded, and partially

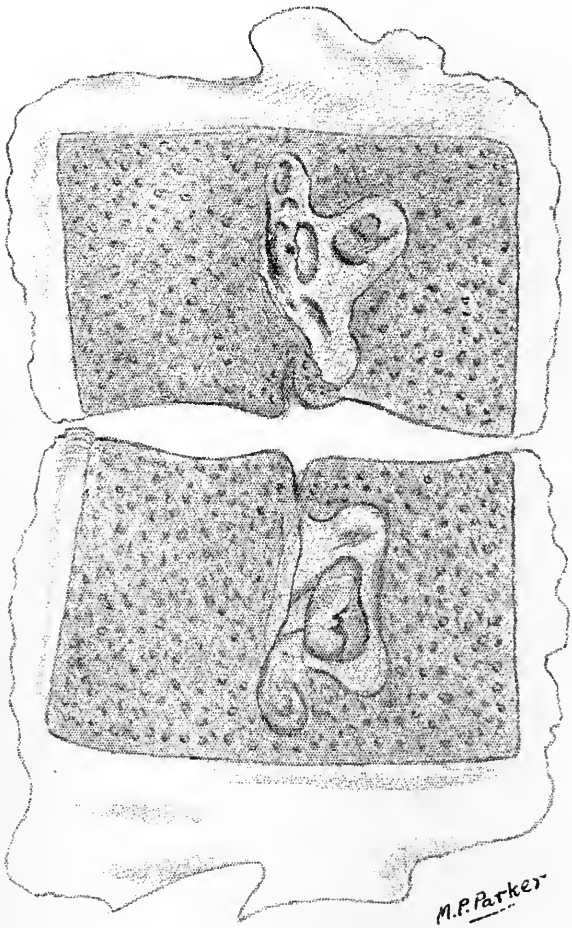


FIG. 9.—Transverse section of two vertebral bodies, showing the Central Form of Tuberculous Osteitis.

or wholly disappear, when their blood-supply is cut off. The number of vertebræ found to be diseased *post-mortem* is generally out of proportion to the external signs. In the dorsal region the average is five to six, and seven to ten are more usual than two only; in the cervical region from two or three to as many as seven may be eroded; whilst in the lumbar region in moderate cases two may be affected, and in severe cases all. Some idea of the number of vertebræ affected may be gained by remembering that the depth of each upper dorsal vertebra is nearly equivalent to two lumbar, and then noting the dwarfing of the affected region.

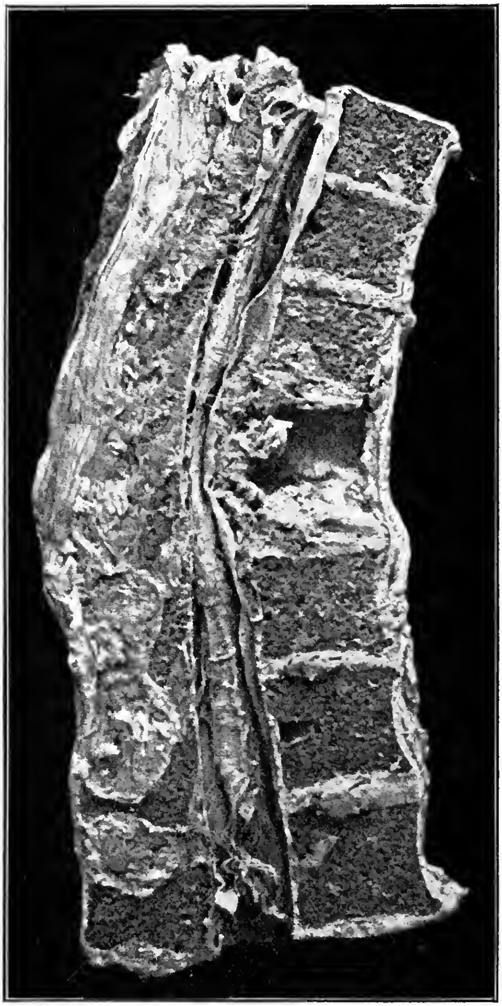


FIG. 10.—Complete Destruction of a Vertebral Body, by the Central Form of Tuberculous Osteitis, leaving the ligaments and the epiphysial discs nearly intact (Wullstein).

The walls of the tuberculous focus are in some cases composed of the bodies of the adjacent vertebræ, and the softened anterior and posterior spinal ligaments and granulation tissue; and the pathological process may be limited by healthy vertebræ above and below, in which event the prognosis is favourable. This particular form of the disease is not uncommon in children of two to three years of age. More often, however, the tuberculous infection spreads beneath the ligaments up and down the spine, causing denudation of the bodies, destruction of the fibro-cartilage, erosion of the bodies with depressions in them. Such creeping infection (spondylitis superficialis of Max David,[1] periosteal denudation of Ménard)

[1] *Grundriss der orth. Chir.* p. 77.

often sub-periosteal, may invade all the vertebræ of one region, and the latter surgeon has seen it extend from the neck to the sacrum. The destructive process rarely passes backwards beyond the articular processes. The anterior parts of the pedicles lie buried in a mass of tuberculous granulations and caseous débris. Embedded in this material may be found spicules of bone, only appreciable on rolling the caseous stuff between the fingers. Rarely are sequestra of any size evident; if present, they are found in cavities of rapid formation, where caries necrotica has gone on. Indeed, it is an observation of common occurrence how seldom a sequestrum is seen in the pus from a psoas abscess. This is a point in prognosis, because if one escapes from its imprisoning walls it is highly probable that there are several more which cannot get away, and in any event the appearance of sequestra implies extensive, rapid, and often incurable disease.

FIG. 11.—Epiphysial form of Tuberculous Osteitis. The morbid process affects the substance of the bodies of the second and third vertebræ (from above downwards) and is extending on either side of the intervertebral disc (Wullstein).

b. The epiphysial origin of tuberculous spondylitis is perhaps the most usual event in the young. Disease begins generally at the posterior parts of the plates, spreads at first forward, and then invades the intervertebral discs, which sometimes escape complete destruction. From the epiphysis the infection rapidly passes into the cancellous body tissue (Fig. 11).

c. The third or peripheral form (Fig. 12) arises in the area of advancing disease. It follows the distribution of the anterior branches to the column, arising from the intercostal arteries. In some instances the first spot of softening is found beneath the anterior common ligament; later the disease spreads beneath this structure from a focus of advanced erosion, and may involve a great part of the length of the column.

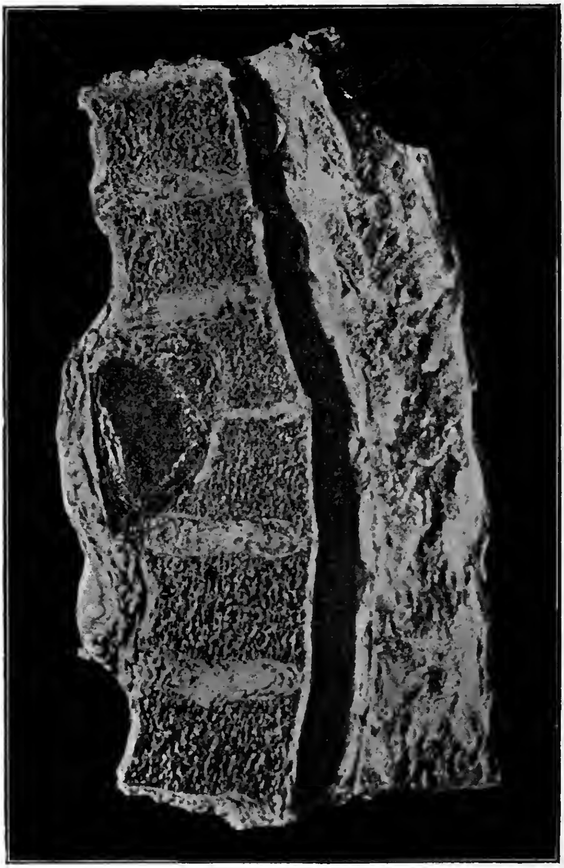


FIG. 12.—Peripheral anterior form of Tuberculous Osteitis (Wullstein).

Events of the Inflammatory Process.—The usual process is for a tuberculous mass of considerable size to form, which becomes yellow and caseous in the centre. This mass consists of broken-down and dead tuberculous material, bony detritus (bone-sand), and pus. We then have the picture of fully-developed tubercle. Where the bone was early affected, is now a hollow cavity, its walls composed of tuberculous or pyogenous membrane, studded with minute tubercles, and its contents are pus, cheesy detritus, bone-sand, grit, and small sequestra. In some cases the mass may calcify, the fluid portion being absorbed.

Very rarely the granulation tissue partially or entirely disappears without the formation of pus. This can only happen when the early miliary tubercles are not so thickly clustered as to cut off the circulation of blood in the affected area. However, we must not assume the presence of caries sicca, because we cannot by the ordinary clinical methods demonstrate an abscess or abscesses. Experience with X-rays has proved that in many cases, in which it was thought that pus was absent, an opaque shadow or shadows in the immediate neighbourhood of the spine has shown the contrary to be the case (Plate IV. p. 105).

In considering the ultimate effects of spinal caries we must bear in mind that we have to deal with two distinct forms of osseous change. (*A*) Tuberculous excavation proper (see Fig. 10), which is seen in its purest form in the dorsal region, because the thoracic cage retards to some extent the collapse of the spine. (*B*) Compression-ulceration due to the coming in contact of the diseased surfaces. After collapse of the column and pathological fracture of the spine a reciprocal modelling and bevelling goes on; this the surgeon may modify by mechanical means. In many cases, however, the tuberculous ulceration (*A*) persists, and rarefying osteitis is still going on; and if a support which has hitherto been in use for some years has been left off, further settling down occurs—a very common experience among those who see much of this disease—and occasionally results in an attack of compression-paraplegia.

Cases of Vertebral Tuberculosis with more than one Centre of Active Disease.—In the practice of the Royal National Orthopædic Hospital we have on nine occasions during the past nineteen years observed cases with double gibbosity of the spine (Fig. 13), and in one instance with three distinct angular projections. The question has therefore arisen, Are such projections due to a widely-spread outbreak of disease in the spine, each tuberculous focus of destruction being connected with the other by a creeping caries running superficially along the bodies, or are they distinct centres developed simultaneously? Ménard[1] says that "if the segment of the spine between the foci remains mobile and is the seat of a

[1] *Étude pratique sur le mal de Pott*, p. 218.

compensatory curve, the foci are unconnected." It must not be forgotten that, as in the case of multiple tuberculous dactylitis, there may be acute dissemination of tubercle in the spinal column, with four or five deposits (Fig. 14). Ménard adds that "a denuding caries in the dorsal region spreads upwards, and in the lumbar region downwards towards the sacrum, but in either case the spreading process is likely to be limited to either the thoracic or abdominal areas."

FIG. 13.—A case in which the Vertebral Column was affected in Two Regions. (Percy E., aged 3 years, Royal National Orthopædic Hospital.) Note the rigid outline of the spinous processes between the projections.

The Natural Methods of Cure.—There are two factors of importance: the first is the cessation of disease in the affected area, and the second is the consolidation of the spine. In some cases they proceed simultaneously, but not in others, for in many instances the spine may consolidate in one part whilst disease spreads elsewhere. We may then ask what amount of time suffices for the cure of the bone-lesions in tuberculous spondylitis? It is a matter of years and not of months. If the duration of cure for hip-disease is fixed at a minimum of three years by many surgeons, then surely the beginning of the consolidation process in spinal disease cannot be less than one to two years. In fact, post-mortem examinations of those dying from spinal disease during the second year show that there is hardly any trace of repair. It is only in the third year that cicatrisation in the tuberculous area is seen, and consolidation follows later, commencing in the posterior parts of the affected vertebral segments and extending forwards. We shall discuss how far ankylosed portions of the posterior parts of the spine may support the vertebral column, and we are prepared to admit that firm posterior consolidation is sufficient, but partial consolidation is not. There can be no doubt that ossification is greater in those cases where abscesses have existed and where mixed infection has taken place.

Tuberculosis in the spine is entirely dissimilar to osteomyelitis and arthritis deformans. Unlike them it ulcerates widely, and new tissue is formed with the greatest difficulty. Before repair can take place, the tuberculous *débris* must be absorbed or replaced by fibrous tissue; and then, and only then, ossification commences. If all the diseased tissue has disappeared, and the diseased vertebræ come in contact, the new fibrous tissue connecting them may undergo calcification and ossification (Fig. 15).

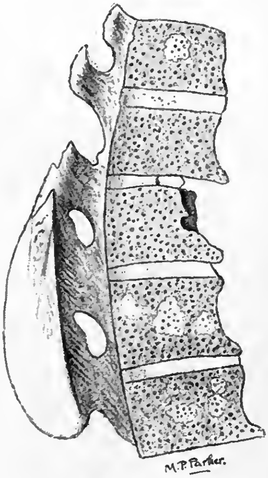


FIG. 14.—Multiple Foci of disease in the vertebral column and extensive superficial erosion (Guy's Hospital Museum).

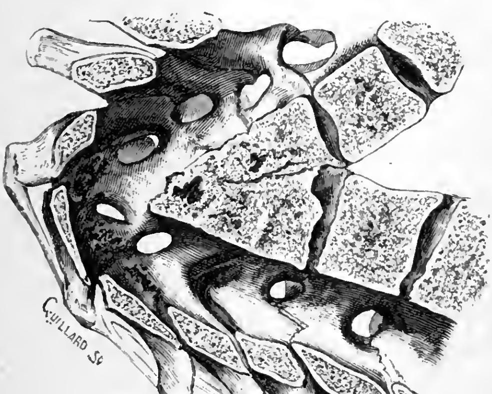


FIG. 15.—The Natural Cure of Tuberculous Caries. Severe Angular Deformity, extensive destruction of vertebral bodies, followed by Bone Ankylosis; note, however, that the spinal canal is of good width opposite the bony projection backward (Rédard),

Spondyl-Arthritis.—This form of tuberculous spondylitis is seen almost exclusively in the occipito-atloid and atlo-axoid articulations, and occurs usually between fifteen and twenty-five years of age. It affects males twice as frequently as females. It begins in the form of an ordinary tuberculous joint affection, and subsequently spreading from the synovial membrane, invades the bone. Undoubtedly the discs of the third and other cervical vertebræ may become invaded secondarily to the bone, and partially or wholly disappear.

Affection of parts of the vertebræ other than those mentioned above is unusual; but the spinous or transverse processes alone may suffer. Disease may also occur in the costo-vertebral articulations and extend thence to the vertebræ. We are enabled to state then that the disease starts in the bodies, rarely in the laminæ or processes.

The Symptoms and Signs of Tuberculous Caries

The family history of the patient must be carefully inquired into, and his own record of illness duly noted; whilst in all cases a thorough examination should be made for evidence of tubercle elsewhere. Thus, in a doubtful case of spinal mischief the writer noted a small depressed scar over the ribs, and this served to confirm his suspicions of the nature of the spinal symptoms. The opsonic index and a skiagram should also be taken.

The "Latent" Period.[1]—For a considerable time before any suspicion is directed to the spine, and long before any of the more marked signs are present, there are certain events which may cause a careful observer to be on his guard. Thus, a child whose family history is not free from tubercle, has an attack of measles, scarlet fever, or chicken-pox, and does not recover a condition of full health. He is easily wearied, and often after slight exertion. He lies down after ordinary exercise with a feeling of relief. He cannot localise the feelings of fatigue or weariness, but he must rest. His appetite falls off, he becomes thinner, and if the temperature be taken regularly at night there is often some pyrexia, more especially if the rectal method be used. The same condition may be observed at times in those who have been exposed to infection by tuberculous parents, brothers, and sisters, and above all, by a tuberculous nurse. The duration of this latent period varies from six weeks to six months, and it corresponds with the invasion of the tubercle bacillus, and perhaps of softening of bone. In some instances, rare it is true, a tuberculous focus remains entirely latent for a time until the sudden appearance of an abscess or the onset of paraplegia draws attention to the condition. Ménard[2] mentions a case of

[1] Cf. the "Pre-deformity Stage" of Chipault, although this embraces rather more than that which is described as the "Latent Period."

[2] *Op. cit.* p. 202.

double invasion of the spine where the dorsal disease was evident to all. The patient died, and on examination an entirely unsuspected focus was found in the cervical region.

Method of Examination.—(1) The attitude and mode of progression should first be carefully observed. We cannot do better than quote the graphic description of Professor Sayre:[1] "When walking about the room, the child will reach with his hands from one article of furniture to another, making careful calculation that he

Fig. 16.—Anterior view of a patient suffering from Cervico-Dorsal Caries, showing the Deformity of the Chest in cervico-dorsal caries and the Lateral Deviation of the Head.

Fig. 17.—Back view of a patient suffering from Cervico-Dorsal Caries, the Squaring and Elevation of the Shoulders are seen.

shall not be deprived of the support furnished by one article before he receives support from another. If he cannot obtain support by catching hold of various articles within reach, he will rest his hands upon his thighs, in order to transmit the weight of the head and shoulders through the legs to the ground, thereby giving them support without bearing upon the diseased vertebræ." We have often noted, when seeing out-patients, that children in the progressive stage will clutch at once at the writing-table as soon as released from the mother's support; and, on the converse, we always

[1] *Op. cit.* p. 364.

take it as an encouraging sign, if after a course of treatment the child, on being brought for examination, stands alone for a minute or two. The mother often says that the child, in resting, adopts unwonted attitudes, such as leaning the arms upon a chair or seat, holding the head with the hands, or putting the hands on the front of the thighs and stooping or squatting according to the region affected. The attitude assumed is due to an effort on the part of the patient to prevent any jarring of, or increased pressure upon the affected part. He places himself, as Professor Sayre says, in a "muscular splint." If the upper cervical vertebræ are affected, the head is oftentimes drawn to one shoulder, and the case may be mistaken for wry-neck due to contraction of the sterno-mastoid (Fig. 16). Error may be avoided by noting that in spinal disease the face is not turned away from the affected side, as it is in ordinary "wry-neck," and it has lost its freedom of movement in all directions. If the lower cervical or upper dorsal region is diseased, an effort is made to balance the head as much as possible; the chin being pushed forwards, suggesting "the position of a seal's head when out of water" (Bradford and Lovett). The attitude when the disease is in the mid-dorsal region is described above. An early affection of the lumbar region is often characterised by some lordosis, and a curious sidling gait is not uncommon, due to irritation and contraction of the psoas and iliacus muscles; marked contraction of the psoas, giving rise to persistent flexion, should be regarded as evidence either of distinct psoitis or abscess. In the effort made to avoid jarring, the patient often walks on his toes with flexed knees. The child should now be stripped; in an adult it is convenient to have a loose skirt hanging from the hips, and put on after removal of the ordinary garments. We may now proceed to test for other symptoms.

(2) *Muscular Rigidity.*—Of all signs this is the most valuable. It is present from the first in the erectores spinæ, and especially in the parts adjacent to the affected area; and, later it is found limiting the movements of the vertebræ. Muscular rigidity[1] is detected by palpation; and, as Wullstein remarks, by stroking the sulci paraspinales. Another way of testing for muscular rigidity is the following:—If in a normal spine the hand be placed palmwise on several vertebræ, and the patient be directed to bend forwards,

[1] *Op. cit.* p. 211. Ménard points out that in early cases, if the patient has been in bed for some time when first seen, the muscular contracture may have disappeared, and so a wrong diagnosis may be made.

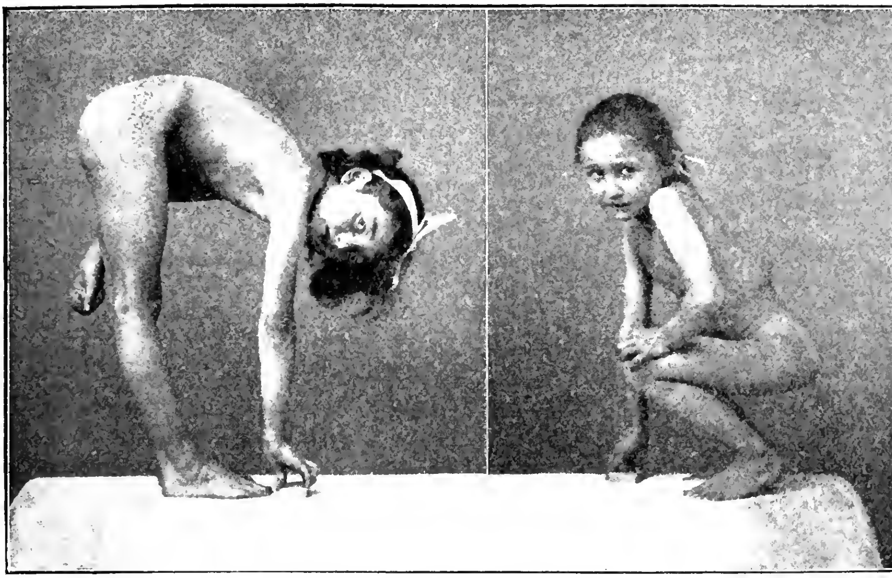


FIG. 18.

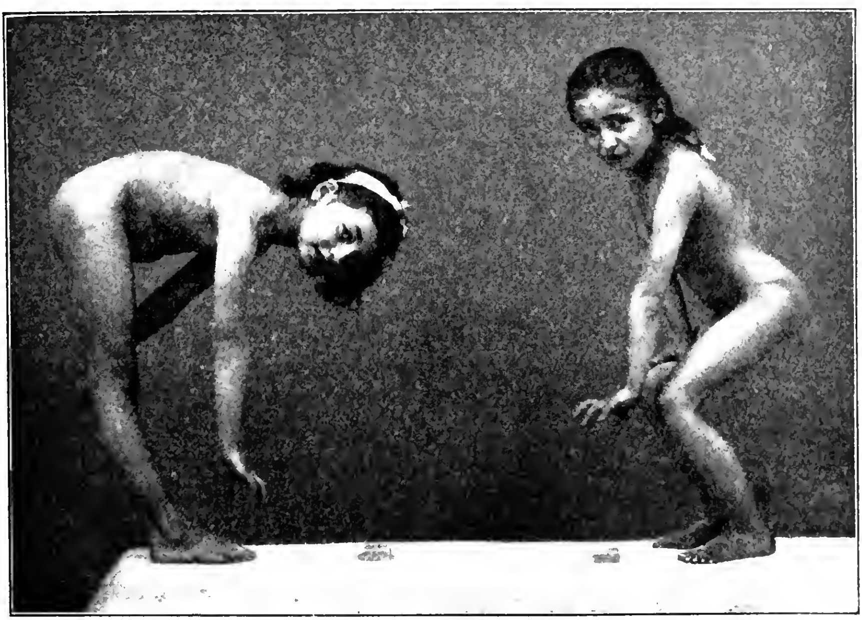


FIG. 19.

Illustrating the Rigidity of the Spinal Column in Vertebral Caries. The children are picking objects from the floor. The contrast between the attitudes in health and disease are seen (Wullstein).

the spinous processes move individually; and when the body is brought back to the upright position, the vertebræ are felt to come successively into position. Now, in a diseased spine this is not the case. On placing the hand on the spine, and examining it carefully in the manner described, when the affected region is reached, three or four vertebræ are felt to move *en bloc*; they move forwards and come back *in one mass.* With practice this sign serves to detect even the earliest cases. A graphic method of determining the immobility of affected vertebræ is to dot the tips of the spinous processes with ink, while the patient is in the upright position, and then to direct him to flex the spine. Normally the distance between the dots should increase proportionately. In a diseased spine the distance between the dots at the affected area does not increase at all, or is less than in the healthy parts. Muscular rigidity[1] is the "advanced patrol" of disease, and the mobility should always be tested if the patient complain of pain in the abdomen or chest, and no cause for it be found there.

In more advanced cases the rigidity is demonstrable by the common manœuvre of inviting the child to pick up a small article from the floor (Figs. 18 and 19). A very noticeable symptom due to muscular rigidity is the short grunting, almost spasmodic respiration of these children when standing or sitting, especially if the disease is in the lower cervical or upper dorsal region. This grunting is at once relieved by laying the child across the surgeon's knees in the prone position, with the arms over one thigh and the legs over the other. The surgeon then separates his thighs gradually, thus making extension on the patient's spine, and taking off the pressure on the intercostal nerves, with the result that the breathing becomes at once tranquil and somewhat full. On closing the limbs again the jerky respiration returns.[2]

In early cases, it is advisable to test the extensibility of the spine by laying the patient prone on a couch and *gently* raising the feet and lower extremities, so as to hyperextend the lumbar vertebræ. In disease, a point will soon be reached when pain is elicited (Figs. 20 and 21). If the psoas or quadratus lumborum is affected, extension of the back in the way just mentioned is nearly or quite impossible, and any attempt to do so gives rise to pain. To test the flexibility of

[1] Ridlon and Jones, *Philad. Med. Journ.*, vol. i. No. 18, p. 777, remark, "Rigidity is the first symptom to appear and the last to disappear. When it has subsided the case is cured."

[2] I consider this is a very valuable sign, and have often proved it; for this we are indebted to the late Professor Sayre.

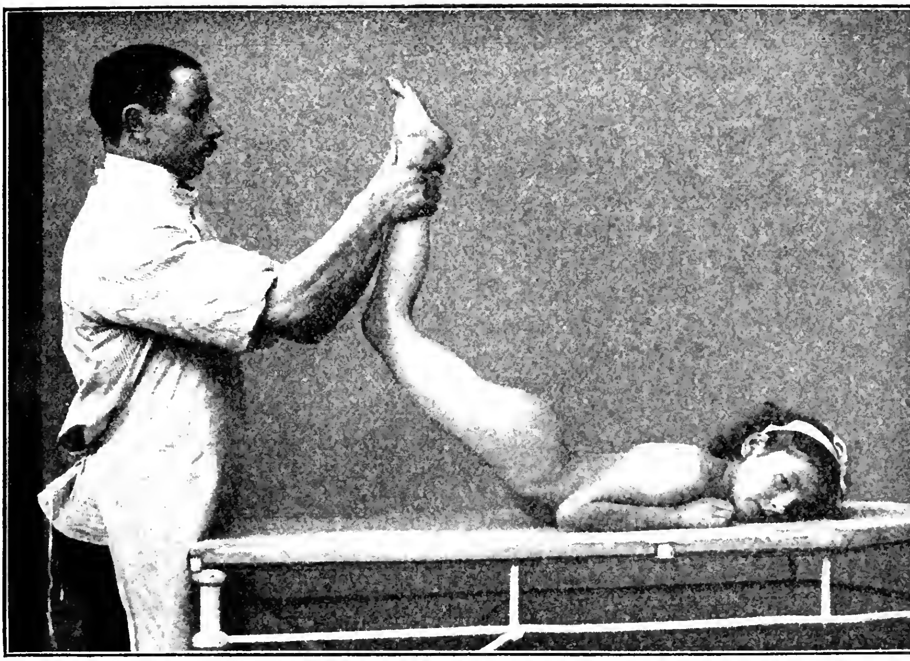


FIG. 20.—Illustrating the Range of Hyper-extension of a Normal Spine (Wullstein).

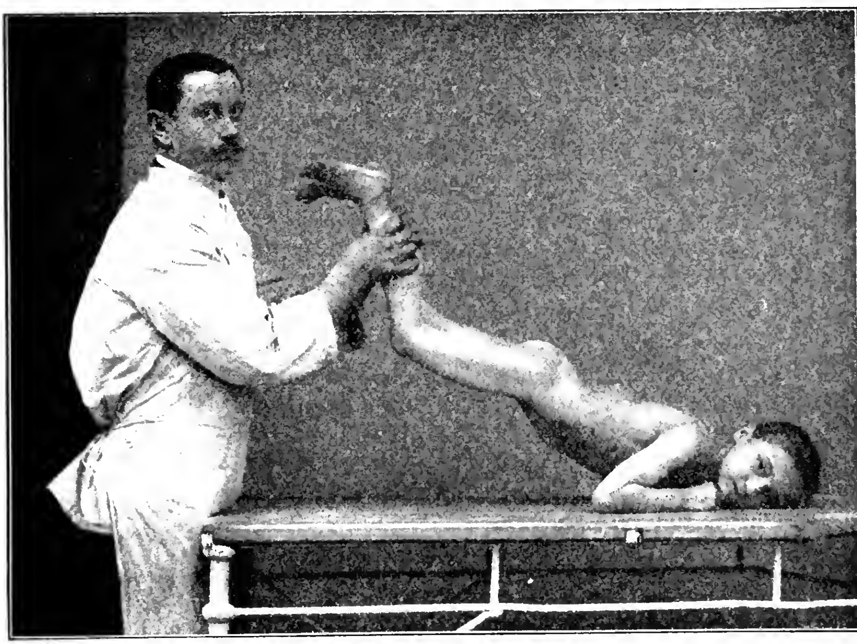


FIG. 21.—The Loss of Hyper-extension of the Lumbar Spine in Vertebral Caries (Wullstein).

the spine the child should be seated with the legs extended, and he should be asked to touch the toes with both hands, the upper extremities being fully extended, and at the same time he should place the head fully back. It should not be forgotten, however, that the movements in the lower cervical and upper dorsal portions are naturally limited, and unless careful examination be made here, rigidity may be overlooked.[1]

(3) *Pain.*—Subjectively, this is present in the majority of cases. Occasionally it is absent altogether, even with considerable rigidity of the back; or there may be merely weariness and slight aching. "Reflected" pain in spinal caries is often a misleading symptom. It is almost axiomatic that the diagnostic value of reflected pain is much greater in spinal disease than is local pain. Reflected pain takes the form of headache over the occiput in cervical disease, or of shooting pains in the arms; of sternal pain or "neuralgia in the side" in dorsal disease; of dry "belly-ache" or girdle pain [2] in the dorso-lumbar, and of growing pains in the legs in the lumbar form of the affection. These pains are essentially "nerve-root" in origin. When they occur, the whole course of the affected nerve or nerves must be examined with precision. The pain is sometimes acute, more often subacute, and it is liable to sudden increase; hence the sudden startings, especially at night; although it must be admitted that "night cries," or rather "early evening cries," in Pott's disease are comparatively rare as compared with other forms of chronic joint affections.

Objectively, pain is elicited by pressure over the individual spinous process. The value of this sign is overrated, and it is not to be compared for diagnostic purposes with rigidity. It is often absent in well-marked cases, whilst an hysterical girl will complain of pain on being touched [3]; and if pressure be made on the processes alone a faulty conclusion will be formed.[4] Another method of testing

[1] Jordan Lloyd of Birmingham, *Med. Rev.*, Apr. 1897, states that in suspected disease in the cervical region, stiffness in nodding suggests occipito-atloid disease, in looking over the shoulder atlo-axoid, and in carrying the eyes back along the ceiling disease of the remaining cervical vertebræ. Bony rigidity is a later event.

[2] Cf. Hilton's *Rest and Pain*, 3rd ed. p. 93: "A gentleman whom I saw from the neighbourhood of Norwich with disease of the spine, in detailing his case to me, said: 'Did you ever see any of those Italian fellows, with monkeys on boards, dancing to music, with a cord or piece of leather strapped tight around their belly and loins? That is just how I felt'; giving one an idea of the pinched and contracted condition of the abdomen which he had experienced."

[3] The naturally hyperæsthetic spots in the spine are mentioned on p. 72.

[4] Chipault, *Manuel d'orthopédie vertébrale*, pp. 50 and 51 *et seq.*, describes local pain on pressure (*douleur provoquée locale*), as being constant at the site of Pott's disease.

for pain is to use a sponge wrung out of very hot water, which being brought over the site of disease gives rise to a sudden sensation of pain. Ice applied is said to do the same. Lüning and Schulthess state that the application of the electrode with a constant current has a like effect. None of these tests are reliable. Their absence does not exclude caries, their presence is often due to other conditions. It is possible that a very sensitive surface-thermometer might indicate some local rise of temperature, although we have had no personal experience with this method. By gentle movements of flexion, extension, and rotation, some pain is often elicited. The method of jarring the spine by sudden pressure on the vertex in the erect position is as cruel and unnecessary as the jarring of the extended thigh in suspected coxitis. If disease is present, other symptoms have already decided the issue; if absent, sudden pressure on the top of the head is very uncomfortable and displeasing to the patient. Ashby and Wright[1] remark: "In a few instances we have found herpes zoster occurring in connection with caries of the spine; and it is worth while to examine the spine in cases of shingles, since they may be a result of lesions starting in the spinal column." A sudden increase of pain is often symptomatic of the formation of abscess, increase of deformity, or

FIG. 22.—Disease of the Lower Dorsal Region. The earliest indication of deformity (Whitman).

He says: "If the child be bent slightly forward and the spine be palpated, on arriving at the diseased area a deep-seated pain is felt, which indicates the exact position of the tuberculous focus."

[1] Ashby and Wright, *op. cit.* p. 567.

of the beginning of paralysis.[1] When treatment is effectual, the first result is gradual decrease with final loss of pain.

(4) *Irregularity of the Spinous Processes, or Projection of one or more of them. Alteration of the Normal Curvature, either Flattening or Increase.*—If, with the above symptoms, and especially with rigidity of a portion of the spine and pain, one or more spinous processes are unduly prominent (Figs. 22, 23, 24), then the disease has declared itself. A sharp, quickly formed prominence indicates rapid

FIG. 23.—Incipient Pott's Disease. Showing the break in the contour of the spine, of which the normal flexibility is but slightly impaired (Whitman).

destruction of one or more vertebræ. A projection of one spinous process is seen occasionally in scoliosis at the point of intersection of two opposing curves (see Fig. 25). Such a projection is quite unlike the sharp knuckle of a displaced spinous process from caries. The natural prominence of the seventh cervical and neighbouring spines should not be forgotten, nor the difficulty of feeling the bony tips in fat children in the dorso-lumbar region. In any case, the projection of one or more spinous processes is best marked in the

[1] Cf. Bradford and Lovett, *op. sup. cit.* p. 21.

dorsal region, as the natural curve has its convexity backwards; whilst the converse is the case in the cervical and lumbar regions, and considerable displacement often occurs before a spinous process becomes prominent, owing to the thickness of the muscles and the natural anterior curve.[1]

(5) *Thickening around the Affected Vertebræ*[2] is absent in the

FIG. 24.—Pott's Disease of the Middle Dorsal Region at an early stage, showing slight increase of the Dorsal Kyphosis, without noticeable change in the attitude (Whitman).

FIG. 25.—Scoliosis, with Projection of two spinous processes.

early stages, but, in our experience, it is generally to be felt whenever there are one or more outstanding spines. It is useful to be able

[1] See p. 80, where Ménard's experiments are detailed.

[2] Lüning and Schulthess, *Chir. orth.* p. 345, observed in a case of one-sided atrophy of the tongue. At the post-mortem examination there was evidence of neuritis in the hypoglossal nerve which passed through an infiltration-zone below the base of the skull.

to recognise it if any doubt exists as to the diagnosis between Pott's disease and scoliosis; such thickening is almost unknown in scoliosis. The presence or absence of thickening should always be ascertained; for, when present, it indicates that the disease has been of considerable duration, and that osteophytic deposits have taken place about the posterior segments of the affected vertebræ.

(6) *Yielding of the Spine on Pressure.*—In the aggressive stages of caries, if the palm of the hand is gently and firmly pressed over the posterior projection it is felt to yield somewhat. As repair and healing take place, the yielding is replaced by a distinct resistance which eventually becomes complete. This sign is of value in two ways. If the yielding is great, it means that several vertebræ are affected and the prognosis will be guarded. When resistance is complete, the treatment may be less rigorous.

To sum up the method of examination. Note the patient's aspect and walk on entering the room; observe the attitude he assumes at rest; remove the clothes from the trunk in an adult, and entirely from a child; test for muscular rigidity, and regard it as the first and most important symptom, the "patrol" of disease; trace pains to their sources; search for any irregularity of the vertebræ; estimate the resiliency of the spinal column at the affected part; place little reliance on the history; and be on the look-out for abscesses and paralysis.

Other symptoms are sometimes present. We have dwelt on the peculiar grunting respiration. In addition, cough is not unusual, also dyspnœa, gastric disorders, flatulence, obstinately recurrent vomiting, and bladder troubles.[1] Fixed dilatation or contraction of the pupil has been observed by Charcot and Gowers in cervical caries.

The *general condition* is one of malaise or distinct illness. Loss of appetite, sleeplessness, inability to get about, are the causes of this; in addition to the depression of the vital powers produced by the disease in some tuberculous cases. The temperature is often raised slightly in the evening, and a hectic appearance may be seen. Bradford and Lovett,[2] as the result of 1050 observations made at the Children's Hospital at Boston, state that pyrexia is generally present in the afternoon in cases under ambulatory treatment. The rise is from 1° to 3° in average cases, and occurs independently of

[1] Cf. Bradford and Lovett, *op. cit.* p. 20: "In one notable instance the operation for stone in the bladder—lateral cystotomy—was performed. No vesical trouble was discovered, but at the autopsy caries of the lumbar vertebræ was found."

[2] *Orthop. Surg.* 2nd ed. p. 23.

the presence of abscess. The pyrexia is often diminished or disappears when the patient is put to bed. Even in some cases when abscess exists there is no evening fever, and it is only when the abscess is on the point of bursting that the temperature rises, thus pointing to mixed infection of the abscess contents.[1]

[1] Max David, *Grundriss der orth. Surg.* p. 82.

CHAPTER III

TUBERCULOSIS OF THE SPINE—(*Continued*)

Deformity and its Causation, Experimental Production—Compensation Curves—Effects of Deformity on the Trunk—Abscess, Causation, Varieties, Course—Paralysis, Causation, Varieties, Symptoms—Other Sequelæ of Vertebral Tuberculosis—Diagnosis—Prognosis.

The further clinical history of vertebral tuberculosis comprises the study of three conditions: deformity, abscess, and compression paraplegia. By some writers they are classed as symptoms, by others as complications. We are disposed to agree with the latter. If tuberculous caries is recognised early, and the case is placed under efficient treatment at once, the disease is arrested, and these disastrous conditions do not arise.

Deformity

Although it is not always present, yet in the majority of cases it is by far the most marked feature of the disease, and its appearance may be the first sign which alarms the patient and leads him to seek advice. R. Whitman [1] estimates that not more than five per cent of the cases are seen before deformity sets in, and the special train of symptoms in early spinal caries is such that they are either overlooked, neglected, or referred to other causes. Frequently no diagnosis is made, and no treatment is initiated until the formation of a posterior projection renders the case clear to the veriest tyro. This, we do not hesitate to say, is lamentable; and although we are not disposed to affirm that all cases discovered and treated early will recover without deformity, yet we are quite certain that it is in most cases preventable by early recognition of the disease and its *thorough* treatment. At least such has been our experience in many early cases, which have been watched most assiduously for

[1] *Trans. Amer. Orthop. Assoc.* vol. iv. p. 240.

several years. Recovery without deformity is the ideal result to be aimed at, and is by no means unattainable.

Before we discuss the deformity of Pott's disease we will make some observations on the normal spine, and refer to the interesting remarks of Ménard, or the "Experimental Production of Gibbosities."

In Volume I. we have discussed the functions of the spinal column, its normal curves, its movements, and the inter-relations of the intervertebral discs and vertebræ. We now allude to a few points pertinent to vertebral tuberculosis.

The student should make himself acquainted with those vertebræ which correspond with certain prominent landmarks, such as the cricoid cartilage, the sternal notch, the tip of the xiphoid cartilage, the umbilicus, the spine and angle of the scapula, and these details may be found in text-books on Anatomy. He should note that in infants, and often in adults, the spine of the first dorsal vertebra is more readily felt than that of the seventh cervical, the *vertebra prominens.*

Abnormal, but not pathological, are the following conditions met with in some vertebral columns:—A projection more or less exaggerated of a spinous process, and having no relationship to spinal caries. In some people there is distinct irregularity of the line of those processes, whilst in others, about ten per cent, a natural deviation either to the right or the left is seen. The normal antero-posterior curves are often exaggerated, and this condition is frequently hereditary.

Physiologically normal is the greater sensitiveness of the skin and deeper structures over the second cervical, the sixth cervical, the second dorsal, and the third lumbar vertebræ. Chipault in his *Manuel d'orthopédie vertébrale* quotes two cases illustrating this point. The first was that of a man who had had syphilis, and whilst being rubbed, he noticed a pain at the third lumbar vertebra and consulted Chipault. He, by careful observation, was able to determine that the pain was subjective. The second case occurred to the son of a colleague—a boy aged seven years, who complained of agonising pain at the apophysis of the sixth cervical vertebra. Radiograms were taken time after time, as the father had become infected with the boy's fears. There were no signs of spinal disease, and when attention was no longer directed to the spot, the pain ceased. These cases illustrate a valuable maxim, viz. that in suspected spinal disease, referred and distant pains are of much greater diagnostic value than local ones, for the latter are always open to doubtful interpretations. In examining the spine of a nervous and apprehensive patient, such an one not infrequently stiffens the back involuntarily, and assumes a fallaciously rigid attitude. Ménard has carried out, and recorded in his excellent work, *Étude pratique sur le mal de Pott*, Paris, Masson et Cie, 1900, the results of the experiments bearing upon spinal deformity.

On the Production of Experimental Gibbosities (Hump-Back)

The mechanism of the deformity in Pott's disease is closely connected with that of extension or hyper-extension of the normal spine; the greater they are, the less is the degree of deformity arising from spinal caries. It is a matter of common observation that caries of the upper dorsal region, for example, is very frequently associated with great deformity; and in this region the spine is capable of very little extension, whereas caries in the lumbar, or in the cervical region, even when considerable, is often accompanied by little or no angular protrusion; and in these regions the extensibility of the spine is great. The experimental production of gibbosity, by the ablation of the requisite vertebral bodies, affords an explanation of these facts. First, a word about the relative capabilities of the several spinal regions as regards extension. The **cervical** region can be so hyper-extended, that in a specimen in which the soft parts and cranium have been removed, the odontoid process can be made to point downwards. Normally, hyper-extension is limited by the tension of the soft parts at the front of the neck. Now, it is obvious that unless there were a considerable space between the posterior arch of one vertebra and that of the next one, the attempt to hyper-extend would be frustrated by interlocking; and actually the laminæ in the cervical region are shallow, the spines feebly developed, and the intervals marked. That is to say, the assumption of the hyper-extended position from the erect is possible, because the arches can be *crowded together*.

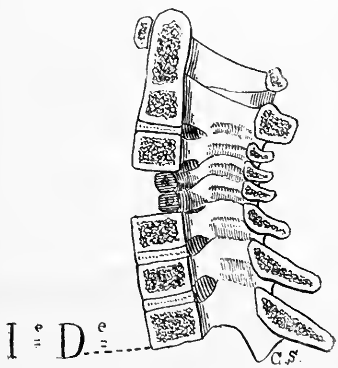


Fig. 26.—Removal of the bodies of the Fourth and Fifth Cervical Vertebræ. The natural interlocking of the arches and apophyses completely prevents inflexion (Ménard).

In the **dorsal** region the intrinsic extensibility of the isolated column composed of bodies and discs is very slight, owing to the thinness of the discs. But, even were this not so, extension is promptly curbed in the intact spinal column, owing to the smallness of the inter-laminary spaces, and the bulk and close setting of the spinous processes.

In the **lumbar** region the discs are thick, the inter-laminary spaces and intervals between the short, quadrilateral spines are large, and considerable hyper-extension can be made before locking occurs. The last three dorsal vertebræ are somewhat lumbar in character.

The bearing of these facts on the deformity seen in Pott's disease has been shown by experiments such as those of Bonnet and Ménard. Thus Ménard found that if one **cervical** body, say the fourth (Fig. 26), was ablated the upper segment fell a little forward, but the third body did not come into contact with the fifth, owing to the interposition of the roots of the pedicles which come off here from the sides of the body. If now, a movement of extension is made, that is, by manual pressure, the arches are crowded together, and form a fresh column of support, the cervical lordosis is restored, and the nett result is shortening by about half the height of one vertebral body. A solid support is afforded, in spite of the fact that the third body does not touch the fifth, and a small gap is left; Ménard speaks of this as "incomplete inflexion." This movement of extension could not occur unless crowding of the arches be possible — the two being, in fact, for our present purpose synonymous. With removal of the fourth and fifth bodies, *plus*

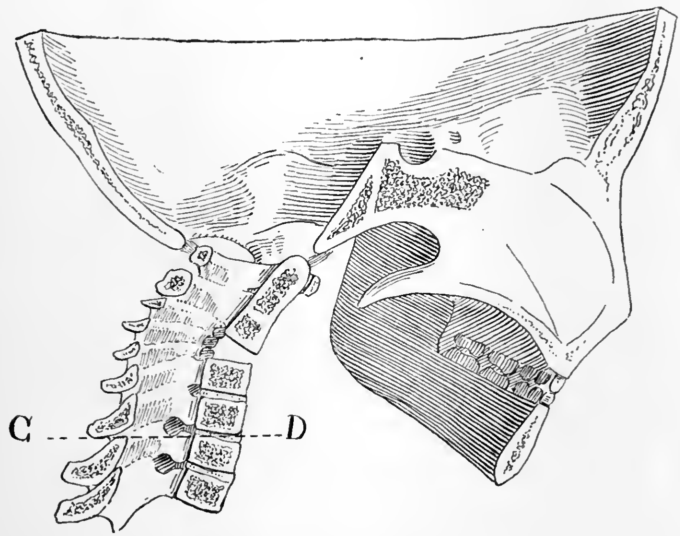


Fig. 27.—Removal of three Vertebral Bodies from the Cervical Region, viz. the bodies of the 3rd, 4th, and 5th segments. Approximation of the remaining vertebral bodies, with moderate "crowding" of the arches. The inflexion is incomplete, because of the interlocking of the transverse processes and the "crowding" of the arches; extension at the suboccipital articulations compensates for the forward bending of the cervical spine (Ménard).

extension, still no angle appears. And even with the third, fourth, and fifth ablated, only the slightest of gibbosities is produced, the inflexion remaining incomplete (Fig. 27).

In the **dorsal** region, removal of one vertebral body leads at once to complete inflexion (Fig. 28). The pedicles in this region, coming off from the back of the body, present no obstacle to the complete descent of the upper segment. The corresponding arch is deprived of its attachments, and this deprivation is all the more complete, since the tilting forwards of the vertebra above frees the superior articular processes of the mutilated vertebra, which is enucleated backwards, and forms a rudimentary gibbosity. With two bodies ablated, the recoil backwards of the detached arches is more marked, and is accompanied by a definite gibbosity and fan-like separation of the spinous processes (Fig. 29). With more than two bodies removed, the inflexion is so complete that the anterior edge of the lowest body of the upper segment rests on the upper surface of the upper body of the lower segment (Fig. 30). With a larger number of vertebræ destroyed, this dislocation may be so extreme that the anterior faces of the lower two vertebræ of the upper segment rest on the upper surface of the lower segment, and the lowest vertebra of the upper segment actually encroaches on the spinal canal, the angle of inflexion being 90° or more. This particular dislocation is only seen in the mid-

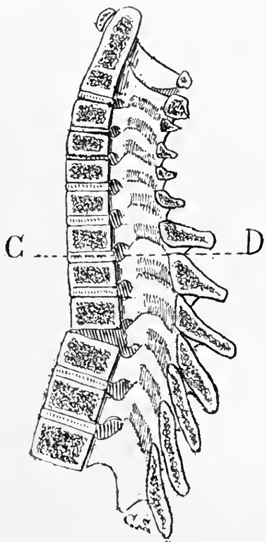


Fig. 28.—Ablation of the Body of One Vertebra (3rd) in the Upper Dorsal Region. Complete Inflexion; fan-like disposition of the spinous processes in the Posterior Projection (Ménard).

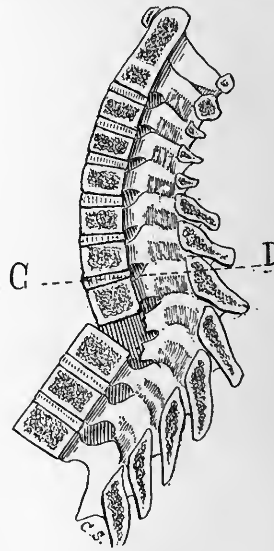


Fig. 29.—Removal of Two (2nd and 3rd) Vertebral Bodies from the Dorsal Region. Complete Inflexion; slight over-riding of the superior upon the inferior segment; fan-like separation of the posterior arches at the summit of the posterior projection (Ménard).

and lower dorsal regions. Ménard attributes it to the resistance opposed to the inflexion by the ribs, and the largeness and closeness of the laminæ —keeping the segments apart during the tilting.

No such neutralising effect, such as we have seen in the cervical region, can be obtained here—the laminæ and spines being normally so close that no further crowding is obtainable. That is, extension cannot be made.

If the ablation is in the upper dorsal region, the tension of the ribs does not prevent complete inflexion, the upper ribs being displaced with the spine and carrying with them the sternum. The lower ribs resisting, however, the lower end of the sternum is pushed forward. This with a generally-marked interscapular gibbosity forms the *poitrine de polichinelle* (Fig. 30).

If the bodies removed are mid-dorsal, the thoracic cage resists complete inflexion, the sternum is carried forward, and a globular thorax results (Fig. 31).

In the **lumbar** region ablation of one body produces shortening,

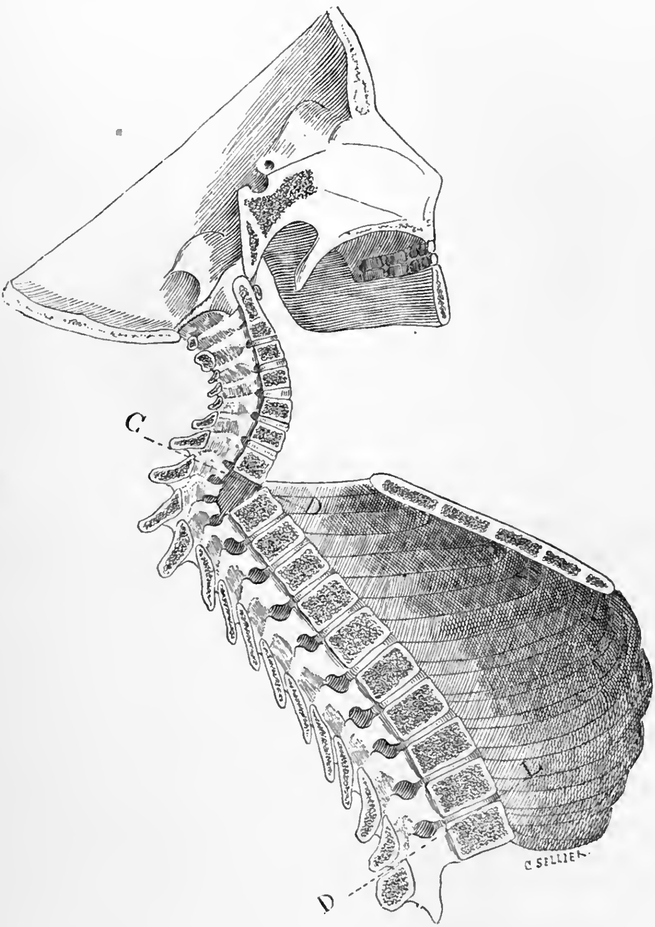


FIG. 30.—Removal of Three Vertebral Bodies from the Superior Dorsal Region. Complete Inflexion, fan-like spreading of the spinous processes. Compensatory lordosis in the cervical and dorsal regions, flattening of the upper part of the chest (Ménard).

provided the arches are crowded together by extension, but practically no gibbosity. If two are removed, complete inflexion results, with an appreciable gibbosity, but relatively to the loss of bone it is very slight.

To sum up, experiments show that, save in the dorsal region, deformity bears no relation to the amount of destruction, and suggest that gibbosities in the cervical and lumbar regions may be expected to be in general feebly developed.

Ménard then goes on to demonstrate the bearing of these facts on pathological specimens. We give with utmost brevity the most striking points :—

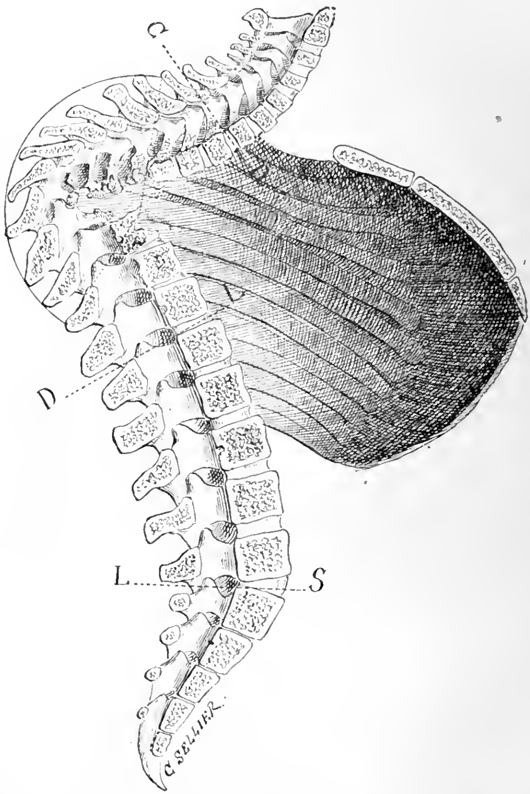


FIG. 31.—Total and partial destruction of the bodies of six Mid-Dorsal Vertebræ. Ankylosis of Four Posterior Arches (5th, 6th, 7th, and 8th) ; Incomplete Inflexion, as the bodies above and below the gap do not touch ; globular thorax (Ménard).

INFLEXION INCOMPLETE

(1) Fig. 53, p. 59 of Ménard's *Étude pratique sur le mal de Pott.* Destruction of six dorsal vertebral bodies, leaving the arches intact. Inflexion 90°, but incomplete, the segments being kept apart by the resistance of the thoracic cage (Fig. 31).

(2) Figs. 54, 55, pp. 60, 61. (Ménard.) Destruction of the five lowest cervical bodies with very little gibbosity. Inflexion is incomplete. Support is given by the superimposed arches (and roots of pedicles in this region).

(3) Fig. 58, p. 62. (Ménard.) Lumbar region. Complete inflexion is prevented by interposition of big sequestrum.
(4) Fig. 59, p. 63. (Ménard.) Lumbar region. Complete inflexion prevented by débris of several bodies.
(5) Fig. 74, p. 83. (Ménard.) Synostosis of arches, helping to prevent inflexion. Synostosis of arches may occur, whilst the disease in front is still progressing.

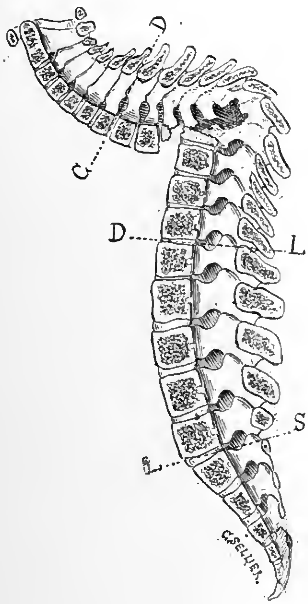


FIG. 32.—Tuberculous Caries of old standing. Partial or complete destruction of the bodies of eight Dorsal Vertebræ. Over-riding of the upper over the lower segment of the spine ; folding of the arches in the posterior spinous projection, and ankylosis of six of them (3rd to 8th) by their articular and spinous processes ; fan-like spreading of the spinous processes at the summit of the projection, and crowding together of them above and below (Ménard).

FIG. 33.—Lateral view of the specimen showing Ankylosis of the Arches of three Cervical Vertebræ ; the articular and the transverse processes are united by bone (Ménard).

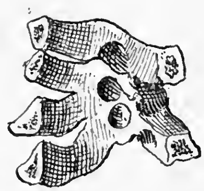


FIG. 34.—Lateral view from the inner side of a portion of bone taken from a case of Cervical Caries, representing a part of the bodies, and of the arches. Two bodies have been destroyed, and those above and below have approached each other, but not completely, because of the ankylosis of the articular and transverse processes (Ménard).

INFLEXION COMPLETE

This comes about sooner or later as general rule. The ends of the segments are reciprocally bevelled by compressive ulceration at the expense of the anterior surfaces.

(6) Complete inflexion, where much destruction is present, must be accompanied by "folding" of the arches (Fig. 32).

(7) Fig. 67, p. 71. (Ménard.) Upper segment overrides lower. This is exceptional.

(8) Figs. 56, 57, p. 62 (Ménard) showing clumps of synostosed arches in the cervical region (Figs. 33 and 34).

Ménard, then, in his experiments on the artificial production of humps or "gibbosities," removed the bodies of various vertebræ, leaving the arches intact, precisely as in spinal caries. He found that in the **cervical** region complete removal of two contiguous vertebral bodies does not produce angular deformity (Fig. 26), and even the removal of three merely results in slight posterior projection (Fig. 27). The explanation of this is somewhat complex. In the first place, the pedicles and transverse processes are attached to the sides of the bodies of the cervical vertebræ, and therefore permit more crowding together[1] of the posterior segments of the vertebræ in extension than in the dorsal and lumbar regions, where they spring from the posterior aspects of the bodies. Then, in the cadaver the removal of one or more bodies together with their anterior and posterior ligaments allows the elasticity of the ligaments of the arches to come into play, and hence very little sinking of the bodies above the gap on to the bodies below takes place. The importance of this experiment in its relation to destruction of the cervical spinal bodies in tuberculous disease is evident; and further, it is probable that the rigidity of the posterior cervical muscles tends to keep apart the vertebral bodies above and below the site of disease, and therefore to diminish the gap in front and the posterior prominence over the affected parts.

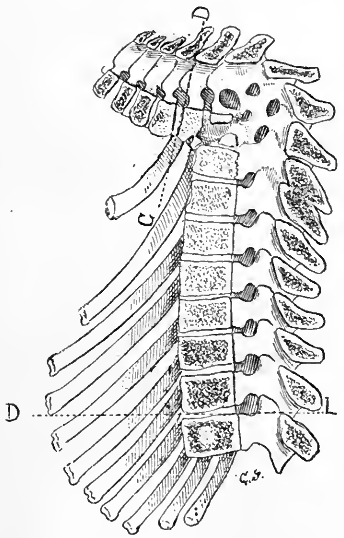


Fig. 35.—Complete destruction of two Dorsal Vertebræ (3rd and 4th) and partial of the 2nd and 5th. Complete Inflexion, the arches are sliding off each other and their spinous processes are separated widely. The articular processes of the 2nd, 3rd, 4th, and 5th dorsal vertebræ are ankylosed, but there is none between the bodies (Ménard).

In the **dorsal** region the converse takes place. Removal of even one vertebral body (Fig. 28) leads, with slight pressure, to a very marked displacement forwards and the formation of a hump. Here the pedicles come off posteriorly, instead of at the sides, and do not form wedges sustaining the column above; so that if the body of one vertebra is removed the angle of inflexion is 25°, if two are removed the angle is 45°, and when

[1] Ménard's expression *tassement* is equivalent to crowding together, and extension of the spinal column in any region involves this idea of *tassement*.

several are destroyed the angle is 90°. Also, the shape and direction of the vertebral arches in the dorsal region do not permit further crowding together of them in an attempt at extension. Fig. 30 shows that after removal of the bodies of three vertebræ complete inflexion takes place, with displacement downwards and backwards of the upper segment on the lower, the absence of crowding together of the arches, and the fan-like spreading of the spinous processes (cf. Fig. 35). In the **lumbar** region some hyperextension is possible, and removal of one vertebral body causes no prominence posteriorly if the spine be extended; further, the origin and shape of the arches is such that crowding together or *tassement* is possible.

These experiments of Ménard founded on those of Bonnet of Lyons are of great interest and importance in explaining the absence of relationship of the size of the boss to destruction of the vertebræ, also the appearance and size of the posterior projection in various regions in spinal caries. The gibbosity will be greatest in the dorsal region. The figures further show how the spinal canal is encroached upon in varying degrees.

The Characters of the Bend at the Site of Disease.—In pathological specimens the results are not quite the same, because the affected area is not so completely circumscribed. A bend may be "incomplete," *i.e.* the upper segment does not come into contact with the lower, and the cavern is filled with tuberculous material, the débris of the bodies, and perhaps pus. This incomplete bend is frequently seen in the cervical region for the reasons given above. By the crowding of the spinal arches, and more or less ankylosis, an auxiliary cervical spine is produced. A bend is complete when the vertebral bodies above and below the site of disease come into contact, and this usually happens if the patient survives long enough. The contact may be destroyed, however, by further ulceration, even after ankylosis of the arches. The bending, whether complete or incomplete, does not result in the posterior segments of the vertebræ being merely crowded together. A distinct and prominent fold is produced, and in extreme cases it appears that the constituent parts are welded together into an osseous mass. Occasionally the bend is not only complete, but there is overriding, the upper body-column passing down behind the lower.

In some cases there is no projection, and this happens more often in adults than in children. In the epiphysial form of the disease the angle may be small, there being only a slight kyphosis present. The deformity may be slight in any case, if the tuberculous process is arrested before considerable destruction ensues; or a vertebra may be hollowed out and become a complete shell; yet, with the cortex thickened, especially by periosteal bone beneath the anterior common ligament, the remains of the body may, aided by the arches, support the body-weight. John Shaw has described as "spurious ankylosis" cases in which even this periosteal thickening was lacking, and the body-weight was supported by the ankylosed arches. Bonnet has stated and claims to have shown that the ligaments are sufficient to support the body-weight until they become softened by inflammatory œdema. A projection sometimes appears quite suddenly, perhaps following injury. The bend of the spine takes place about an axis passing through the articular processes, therefore posterior to the canal, which is not, as a rule, encroached upon. When many vertebræ are involved, the projection is rounded. If the projection is rectangular or nearly so, dislocation of the spine has occurred.

When the projection backwards occurs near the lower end of the spine, the pelvis undergoes characteristic changes. The side-walls approximate so that there is a diminution of the transverse and an increase of the conjugate diameters.

The changes occurring in the *arches are as* follows:—Backward enucleation of the posterior arch of the body, first destroyed by the disease, is often obvious to sight and touch. If two or more vertebræ are destroyed, a fan-like spreading of the involved spinous processes occurs (Fig. 31). In the case of a rounded projection, it sometimes happens that in passing the finger from below upwards a marked rally is felt at the lowest point. This is the lowest arch in the area of disease, dislocated backwards with the remains of the vertebral body, and it marks the inferior limit of complete destruction. The posterior segments of the affected vertebræ are often atrophied, and sometimes ankylosed by new bone thrown out. The atrophy may be "trophic," as in tuberculous hip, or it may be due to the crowding together of the parts.

The nature and extent of the deformity depend upon the site of invasion by the disease, the extent of destruction, the number, and region of the vertebræ affected, and the presence and form of the compensatory curves. The estimation of the number of vertebræ involved and destroyed may be made by noting the size and shape of the boss and counting the number of spines in it. At least, those vertebral bodies corresponding to the projecting spinous processes are diseased and perhaps more. Ménard[1] has pointed out a very valuable sign. He says: "On passing the finger from below upwards along the profile of the projection, on coming to the lowest arch pushed backwards from the area of disease a distinct and abrupt rally backwards is felt in many cases. It is like a step in a staircase (*marche d'escalier*) going from below upwards. Above this point the spinal apophyses are forcibly crowded backwards one upon the other, forming a regular series, until they are gradually lost in the healthy region" (Fig. 36).

FIG. 36.—Dorso-Lumbar deformity of Spinal Caries, illustrating the "Marche d'Escalier" of Ménard.

The determination of the original focus of disease in the projection can be made by observing the distance between the spinous processes. It is always greater at one place, generally the most prominent part of the hump, and this is where the disease originated. This point is usually situated nearer the lower end of the projection for two reasons: creeping caries, at least in the dorsal region, extends upwards rather than downwards, and compressive ulceration is more marked in the upper than in the lower segment of the affected area.

Owing to reasons, experimental and pathological, already given on pp. 81, 86, deformity is always seen earliest and becomes most marked in the dorsal region, then in the cervical, and least so in the lumbar region. If only one or two dorsal vertebræ are affected a very sharp angle is produced, and if many, a more or less rounded projection ensues, which may be of enormous dimensions; whereas the whole lumbar vertebræ may be diseased without any posterior projection of bone being present. In some instances, disease beginning in the dorsal area spreads to other regions either continuously or by successive outbreaks, and the foci becoming co-terminous, a curve involving the whole length of the column results.

Stripping of the periosteum due to peripheral infection and creeping caries may be inferred to be present, if the kyphosis is not

[1] *Op. cit.* p. 80.

sharply limited above and below, and the incurvated region is held immobilised by an unyielding contracture. The original "boss" is a curve of short radius, and the denuded spine above and below presents curves of large radii, which are in marked contrast to the compensatory lordotic curves, if the neighbouring spine is healthy.

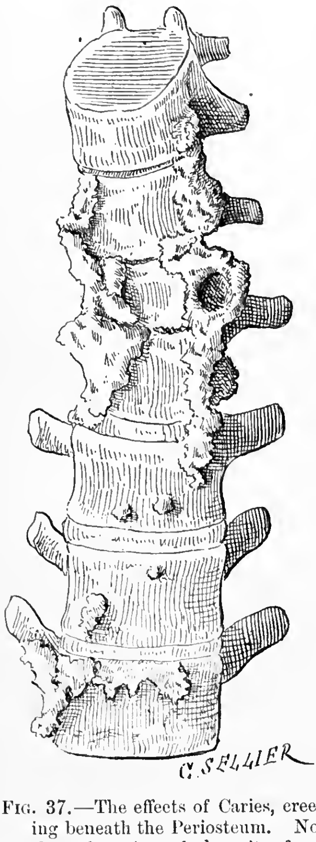


FIG. 37.—The effects of Caries, creeping beneath the Periosteum. Note the sub-periosteal deposit of new bone (Ménard).

It is quite evident that a projection of these characters indicates that the disease is progressive, and according to Chipault[1] is accompanied by pain on deep pressure over the transverse processes.

Compensation Curves.—The deformity of tuberculous spondylitis is, except in those rare cases of lateral deviation, kyphotic. It is compensated by lordosis above and below, which is produced by active muscular contraction at first and adaptive changes later. The compensation is effected ultimately by changes in the shape of the discs. So extreme may this change be that, in a lumbar kyphosis, compensatory lordosis of the dorsal region has been observed. A severe dorsal kyphosis is compensated by exaggerated lordotic curves in the cervical and lumbar regions, and it is a frequent observation, that when the cervical forward curve is greatly exaggerated, the skin of the neck is thrown into transverse folds.

If the deformity is low down in the lumbar region, and there is no room for a compensatory curve below the disease, this is obtained by hyperextension at the hip-joints (Fig. 42). Naturally, compensatory curves give rise to a great shortening of the spine; and the greatest loss takes place when the already kyphotic dorsal vertebræ become badly diseased. In such an event the scapulæ may actually override the iliac bones.

In the case of double foci of disease in the spine, an attempt

[1] *Manuel d'orthopédie vertébrale*, p. 207.

at lordosis between them indicates that they are separated by healthy vertebræ. Lordosis begins when the inflammatory phenomena are subsiding, and becomes more marked on the adoption

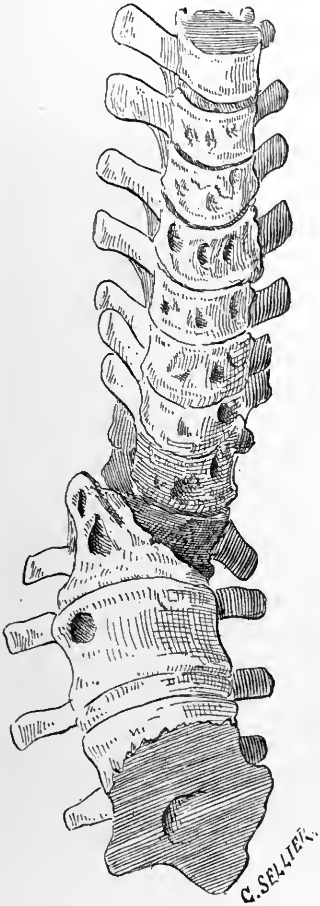


Fig. 38.

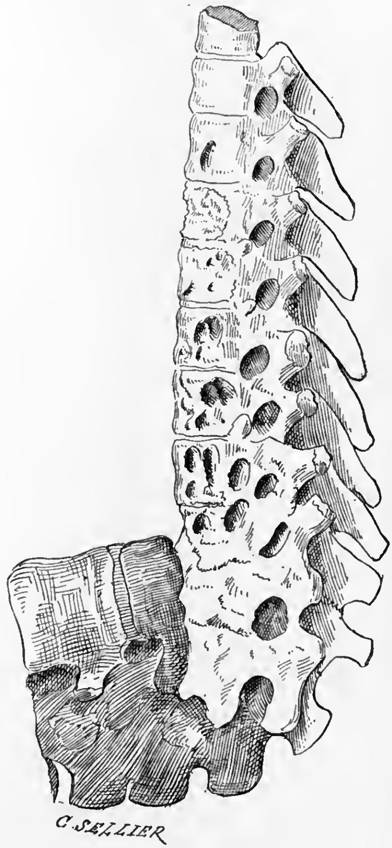


Fig. 39.

Fig. 38.—The effects of Caries, creeping upward from the original focus. Note the secondary excavations, also the lateral luxation of the upper upon the lower segment of the spine (Ménard, from Musèe Dupuytren).

Fig. 39.—A lateral view of Fig. 38.

of the erect position, and more perfect as time goes on. It is better marked in the regions capable of most extension, and is therefore greater in the cervical than in the lumbar region. Once fairly established, muscular retraction and ligamentous changes maintain the lordosis permanently, and the bones undergo modification. Thus the lumbar vertebræ are increased in height and diminished in width.

Multiple Posterior Deformities.—These are, unfortunately, far from rare. They are seen more frequently in infants and in children than in adults, and are of very grave significance. They do not as a rule appear simultaneously, and they are sometimes

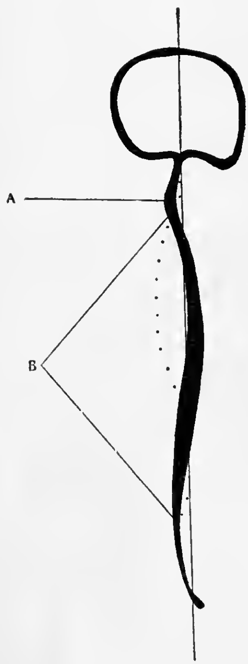


Fig. 40. — Compensation - Curves. A, Direct Deformity; B, Compensatory Deformity. The dotted line indicates the normal contour of the spine (Whitman).

Fig. 41.—Dorso-Lumbar Lordosis, compensatory to cervico-dorsal caries (Wullstein).

situated close together or are separated by a considerable interval. They frequently merge into one another and form an enormous deformity. This occurred in the patient, Fig. 13; in eighteen months' time from the time the illustration was taken. It is seldom that the two projections are of the same size, the upper one is usually the larger and more prominent.

An old-standing antero-posterior deformity is usually rounded, and has on it a bursa of considerable size and density, which is liable to repeated attacks of inflammation and may suppurate.

The conditions which are associated with *increase in the size of the projection* are two, and they occur in different stages of the disease. Excavation of the bodies and pathological fracture account for the earlier; and compressive ulceration, which goes on until healthy parts are reached, accounts for the later increase.

FIG. 42.—Dorso-Lumbar Caries, compensatory flattening of cervical and dorsal spines (Wullstein).

Lateral Deviation in Tuberculous Caries.[1] — Partly because of its intrinsic interest, and partly because of the difficulty of diagnosing this condition from some forms of scoliosis, it is essential to devote some space to the consideration of the subject. Lateral deviation may arise from two forms of ulceration. In the one form, the vertebral bodies at the site of disease are entirely destroyed, and the superior segment of the spine is carried to the right or the left of the inferior, in such a way that the thickness of the anterior segments above and below do not correspond. In the second form the vertebral bodies are eaten away more on one side than the other, so that there is not so much displacement as lateral deviation. There is little or no rotation,

[1] On this subject the following references may be consulted: Kirmisson, *Difformités acquises*, p. 24. Bartow, *Ann. Surg.* 1889, p. 48. Henry Taylor, *Trans. Amer. Orth. Ass.* vol. i. p. 38. Lovett, *Trans. Amer. Orth. Ass.* vol. iii. p. 182, and vol. iv.

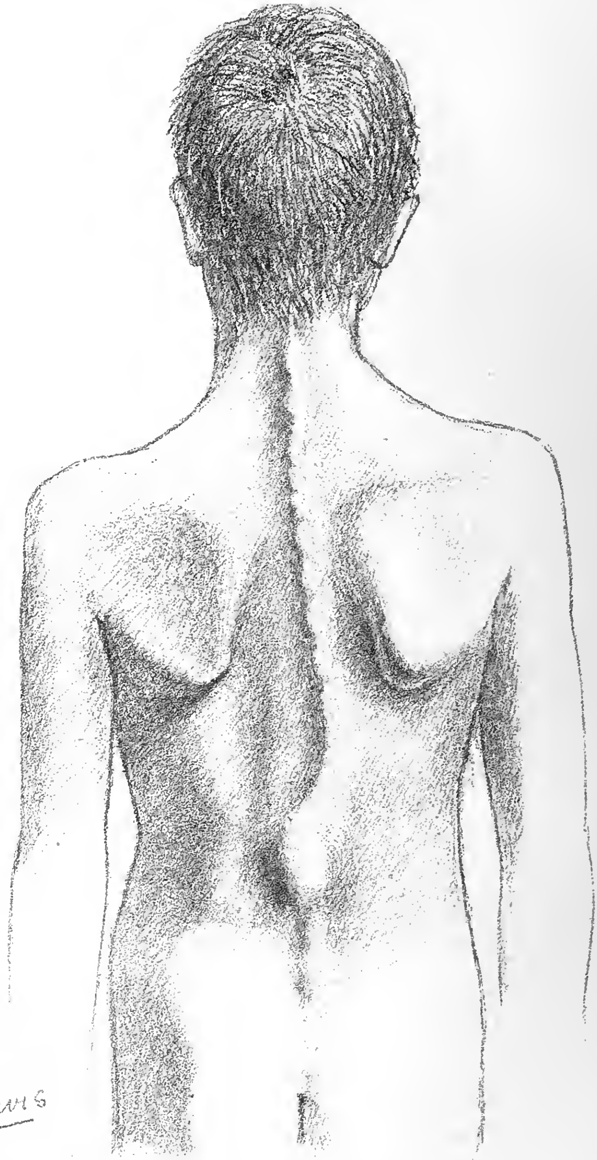


Fig. 43.—Lateral Deviation of Dorso-Lumbar Region in vertebral caries.

p. 38. Ridlon, *N.Y. Med. Rec.*, 17th September 1892, under the title "Rotary Lateral Deformity of the Spine in Pott's Disease." Chipault, *Manuel d'orth. vert.* p. 188. Ménard, *Étude pratique sur le mal de Pott*, p. 72.

although Bernard Bartow asserts the contrary. My observations on fourteen cases do not bear out Bartow's contention. Kirmisson[1] speaks of lateral deviation as being due either to muscular spasm, which disappears on decubitus, or to asymmetrical destruction of bodies, which remains, whatever position be adopted. Clinically, the following points about lateral deviation in caries are worthy of note. It occurs in early and advancing cases, and not in those getting well. When the patient is placed recumbent, it disappears after a time and is replaced by antero-posterior deformity. Rotation is usually absent. When the patient stands, the curve is not sinuous, but it appears as if the upper part of the trunk were sliding off the lower (Fig. 43). Lateral deviation is accompanied, during its progress, by great pain, which diminishes as the deformity disappears. Muscular effort is unable to overcome lateral deviation in caries, nor is it affected except to a slight degree by spinal extension. It is highly important to recognise this form of spinal caries, as it may be a source of much confusion, and some cases have been mistaken for lateral curvature.

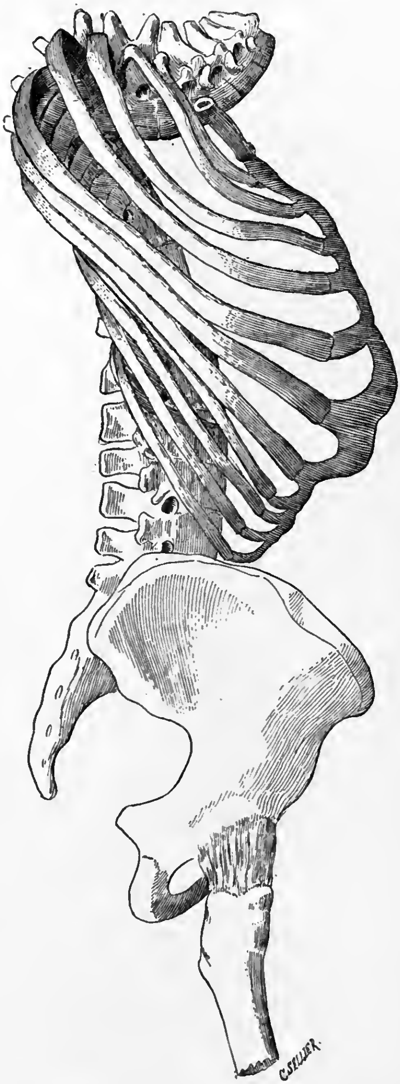


FIG. 44.—To illustrate the effects of spinal disease in the Upper Dorsal Region upon the shape of the Chest, expiratory position, see text (Ménard).

The Effects of Angular Deformity on the Trunk.—*In the chest* three varieties of deformity are seen. *A*. If the curve is

[1] *Rev. d'orthopédie*, November 1892, p. 440.

high up in the dorsal region, the true ribs are held at an angle greater than the normal, the sternum is displaced downward, and

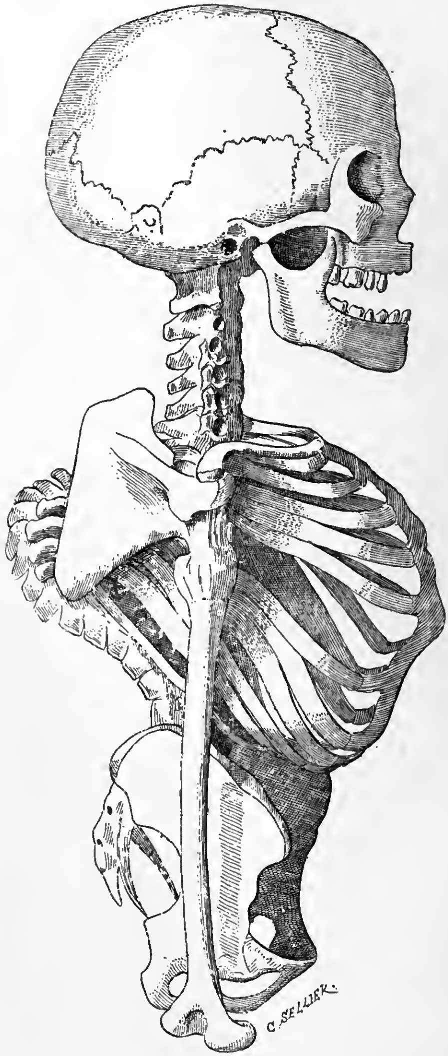


Fig. 45.—To illustrate the effects upon the shape of the Chest of disease in the Lower Dorsal Region. The chest is in the inspiratory position (Ménard).

the antero-posterior diameter of the thorax is diminished (Fig. 44). In fact the chest is in an expiratory position. *B.* If the disease is low down in the dorsal region the ribs and sternum are raised, the antero-posterior diameter of the chest is lengthened, and the chest is barrel-shaped, and is in a position of inspiration (Fig. 45).

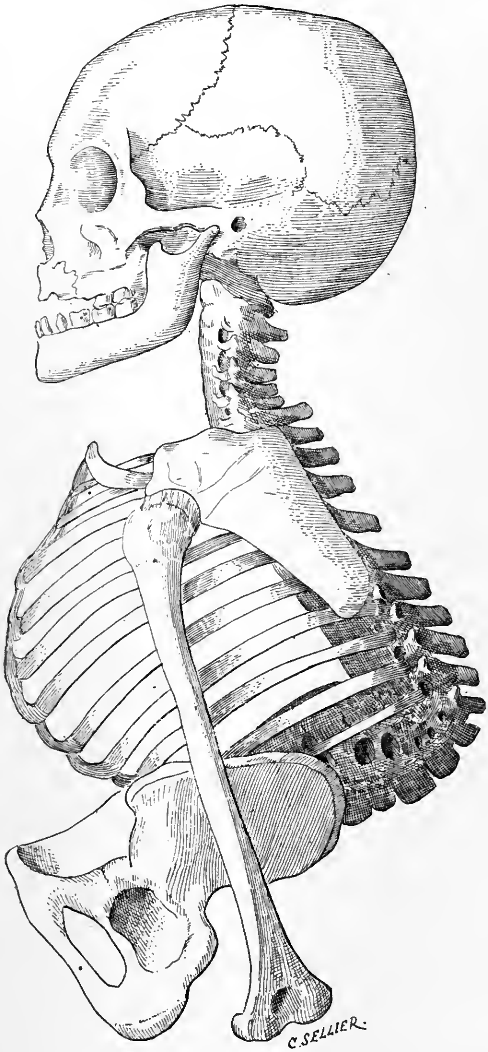


FIG. 46.—To illustrate the effects of Lumbar Spinal disease upon the shape of the Chest, see text (Ménard).

Therefore the breathing is diaphragmatic, and the patient is short of breath. *C.* When the lumbar region is affected the whole thorax sinks downward and forward, the lower ribs override the pelvis (Fig. 46), the ensiform cartilage approximates to the symphysis pubis, and the abdominal wall is thrown into folds. The pelvic changes are described on p. 100. With such structural deviations considerable alterations in the position of the viscera and large blood-vessels must take place.

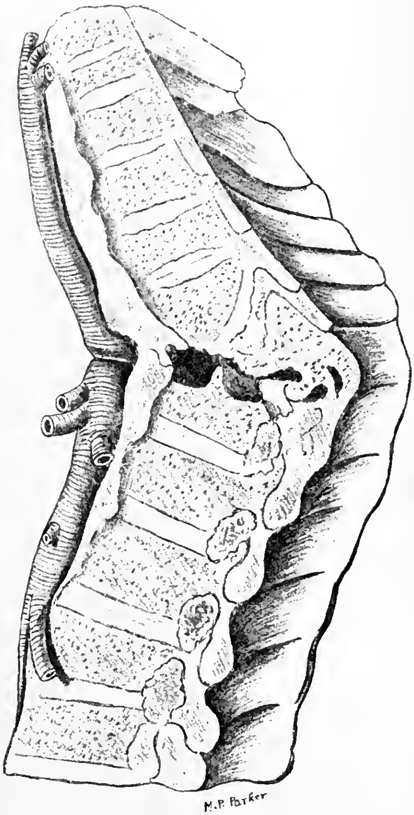


FIG. 47.—The effects of Dorso-Lumbar Vertebral Caries upon the Aorta; it is infolded and kinked (Guy's Hospital Museum).

The Effects of the Deformity on the Heart and Large Vessels.—Very considerable displacement of the heart takes place. We have frequently observed the apex-beat at the nipple, and in two extreme instances of displacement we could feel it in the third intercostal space in the nipple line. The left ventricle, and subsequently the other chambers of the heart, undergo hypertrophy and dilatation on account of the obstruction produced in the aorta.

The alterations in the direction and calibre of the aorta and vena cava deserve notice, because these changes and the associated cardiac effects are responsible for the malnutrition and coldness of the lower extremities in spinal caries. Hilton Fagge [1] drew attention to the "kinking" of the anterior wall of the thoracic aorta (Fig. 47), with hypertrophy of the heart; and Sir J. Goodhart [2] has described a case of invagination of the aorta from above downwards in posterior spinal deformity. According to Ménard, the thoracic aorta may be bent on itself posteriorly with or without lateral deviation, or it may be pushed forwards so as to be convex anteriorly, and still retain its median position; or it may be pushed laterally as well as anteriorly. As the result

[1] Guy's Hospital *Reports*, 1872. [2] Quoted by Ménard, *Mal de Pott*, p. 114.

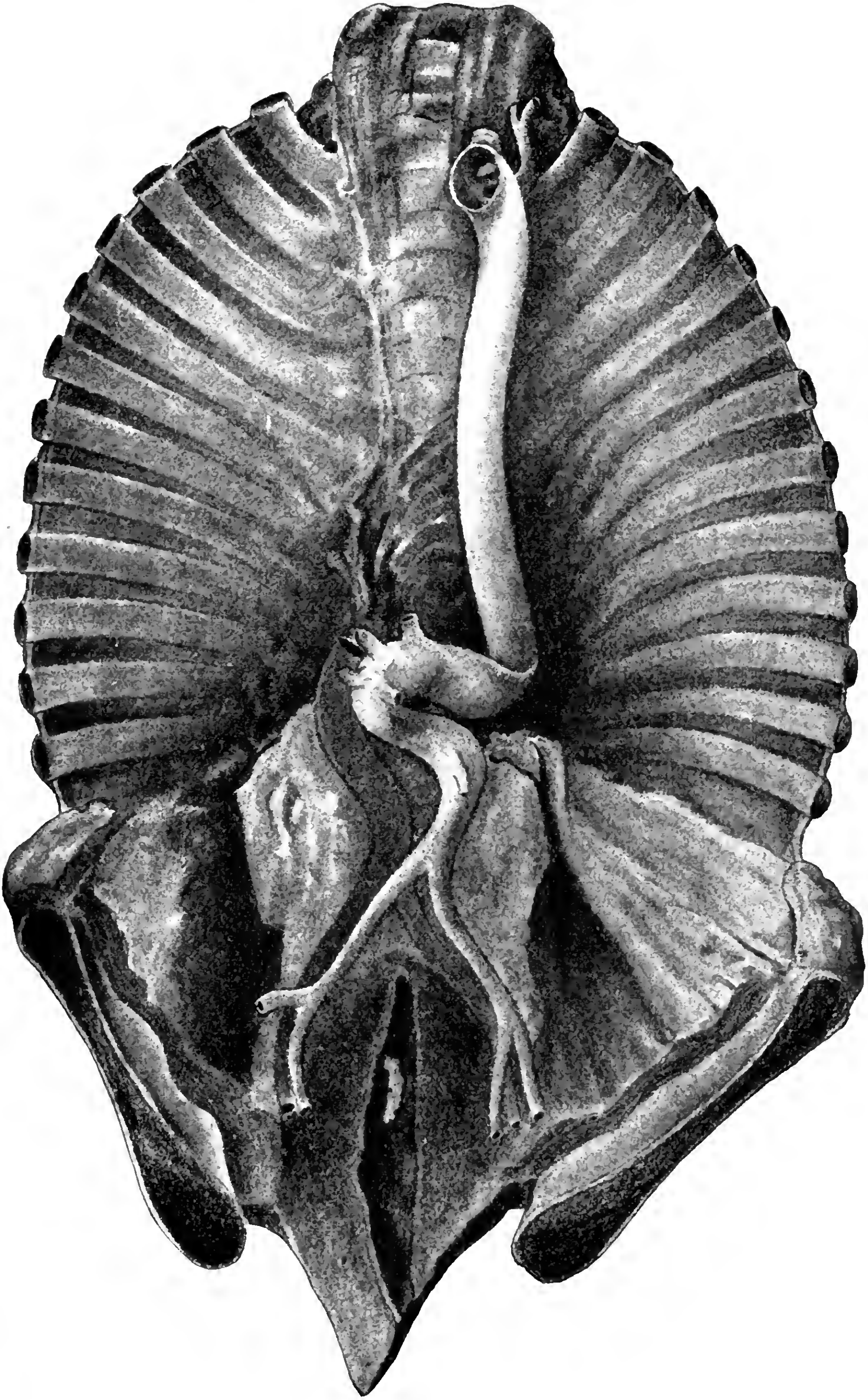


FIG. 48.—Tuberculosis of the Vertebræ with Lateral Displacement. The Aorta is twisted, deflected, folded, and kinked (Wullstein).

of the posterior bending, the aorta is kinked, and in its anterior wall a fold forms, which acts like a valve and obstructs the circulation. When a dorsal abscess is large, the aorta is flattened and compressed, and the vena cava is affected in the same way.

It is well known that arteries traversing tuberculous abscess cavities seldom ulcerate, although their walls are freely bathed in pus. It is asserted that a tuberculous membrane forms on them and covers them like the sheath of a tendon. Whether this is so or not, the fact remains that ulceration into a small vessel is infrequent, and ulceration into the thoracic aorta is excessively rare.

The lungs frequently become compressed, leading to the peculiar grunting respiration, and later on to the incidence of tubercle; the abdominal viscera, notably the liver and stomach, are pushed downwards; and in bad cases the abdomen is very prominent, with much derangement of digestion.

The Effects of Pott's Disease on the Pelvis.—The study of the changes produced is important in the female sex, on account of the probability of pregnancy and parturition. Disease of the cervical and upper dorsal spine produces no effect. When the dorso-lumbar region is affected, certain mechanical results follow. The upper part of the sacrum is carried backwards, the curve of that part is much diminished and sometimes lost, and the lower part of the sacrum is carried forward. The crests of the ilia are carried outwards, whilst the transverse diameter of the pelvis taken at the most prominent parts of the ischia is lessened. In effect, the pelvis becomes funnel-shaped. These changes are the result of the pushing backwards and falling downwards of the sacrum, which causes widening out by wedge-action of the upper part of the pelvis; and the pull of the sacro-iliac and other ligaments, now more oblique than in the normal subject, approximates the lower part of the pelvis, particularly on its lateral aspects. When the disease is lumbo-sacral, the sacrum itself is altered in shape by the destructive effects of disease, and sinks downwards and backwards; then secondary mechanical changes in the lateral walls of the pelvis follow, similar to those described in dorso-lumbar disease. Purely mechanical changes in the outline of the pelvis are seen as the result of dorso-lumbar disease occurring in early life during the ossification of the skeleton, but they do not occur when disease arises after puberty. Disease of the lumbo-sacral region originating at any time of life will profoundly affect the shape and contour of the pelvis (Fig. 49).

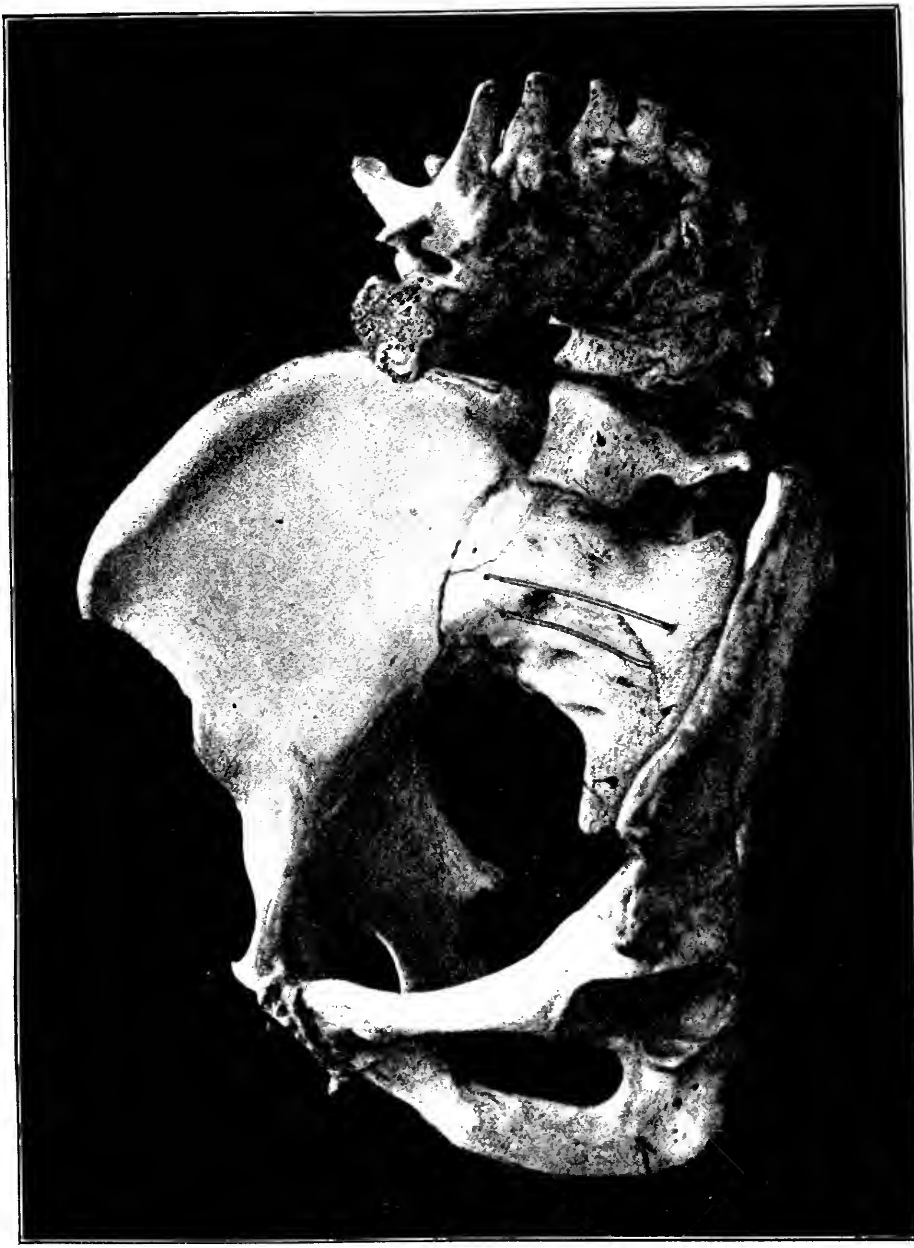


FIG. 49.—Illustrating the effects of severe Vertebral Tuberculosis upon the Pelvis (Wullstein).

Record of the Deformity.—It is essential to keep some record of the spinal deformity from time to time. This is best effected by using a strip of sheet-lead, moderately stout, of more than one foot in length. With the child lying prone, the lead can be adapted to the curved spine. On removal, the lead is turned sideways, and serves as a ruler for an ink-tracing on the record sheet. A better plan in place of the ink-mark is to place the lead sideways as before on a piece of cardboard, and using the lead as a guide, to cut out the curve in cardboard; then place the cardboard against the spine to see if the outline fits the spinal curve. If not quite correct, it should be gradually trimmed.

If the patient is seen early, deformity may be averted; and in every case, if already present, it should be prevented from becoming worse. Much recession of the deformity can be gradually obtained in careful and thorough hands.

Spinal Abscess

Anatomically, tuberculous abscesses in connection with the spine are either *sessile* and close to the osseous lesion, or *migratory* and burrowing; but, in either case they communicate directly with the tuberculous centrum, which in itself is generally an abscess cavity. Clinically, abscesses are met with as closed sacs, though later they too often become, or are converted by the activity of the surgeon, into fistulæ, which are in the majority of cases the seat of mixed infection, tuberculous and septic. Treatment by rest undoubtedly diminishes the frequency of abscess, and even when formed, the liquid portion of the contents undergoes some absorption during recumbency, leaving behind a caseous or calcareous mass. This may light up again, even many years afterwards, and constitutes that particular type of abscess known as the "residual" abscess described by Sir James Paget. Whereas, what may be termed primary abscesses communicate directly with the spine, all residual abscesses do not; for, some are due to the breaking down of the caseous matter left in the track of the previous abscess. The experiments of Garré have shown how highly infective, as regards tuberculosis, the pus of spinal abscesses is, and the bacilli retain their activity for a very long period. The size and contents of an abscess are no measure of the extent of the primary lesion, and a small focus may cause a very big collection of pus.

Frequency.—Briefly it may be stated, from a consideration of the data collected by various authors, that abscess occurs in about one patient in five suffering from Pott's disease. My colleague, Mr. E. Muirhead Little, found that among the in-patients at the National Orthopædic Hospital, many being admitted on account of the abscess, this complication was present in 21 of 133 cases; among 133 cases treated as out-patients, only 7 cases of abscess are recorded.[1] Mohr says an abscess is present in 12·5 per cent, Benthner in 57·6, and Billroth in 59. The wide variation in the figures depends upon how long the cases are watched. In post-mortem examinations, Nebel found abscess in 68 per cent, Bouvier in 86, and Lannelongue in 99. W. R. Townsend[2] tabulated 380 cases of spondylitis; 75 were found to have abscess, distributed thus—in the cervical region 8 per cent, dorsal 20 per cent, lumbar 72 per cent; thus correspond closely with the data given by Michael and Parker.[3] The latter surgeon found that 8 per cent of his dorsal cases suppurated, 30 per cent of the lumbar, and 70 per cent of the lumbo-sacral. These figures strikingly exemplify this point, that the liability to abscess of the various regions of the spine increases from above downwards. So too do the total range of movements and amount of weight borne. Such factors undoubtedly, then, influence the onset of abscess. Bradford and Lovett[4] remark, "The earlier the treatment is begun, and the more efficiently it is carried out, the less liable are abscesses to form; but it must not be assumed that the occurrence of abscess is evidence of incomplete treatment. Frequently an abscess cannot be avoided." Very often the presence of an abscess is not recognisable by the ordinary methods of examination, and occasionally it happens that the sudden appearance of a fluid swelling may be the first sign which calls attention to the spine.

The Course of Spinal Abscesses.—Whilst the site of spinal destruction is usually nothing less than an abscess cavity, the migration and ultimate size of the purulent collection correspond with the activity of the disease, the virulence of the destructive process, and the amount of detritus at the lesion. Wullstein, however, also points out that a small focus of destruction may give rise to a large abscess.

In the Cervical Region.—The point of exit of pus is greatly dependent on the disposition and arrangement of the deep cervical fascia. Attached behind to the spinous processes of the ver-

[1] *Lancet*, 23rd July 1892.
[2] *Trans. Amer. Orthop. Assoc.* vol. iv. p. 164.
[3] *Roy. Med. Chir. Soc., Trans.*, 1884.
[4] *Op. cit.* p. 30.

tebræ, it is continuous with the layers of connective tissue investing the trapezius and deep muscles of the neck. It then crosses the posterior triangle, and dividing into two layers, ensheaths the sterno-mastoid muscle. The layers unite at the anterior border of that muscle, and meet the fascia from the opposite side of the median line. A process of the layer beneath the

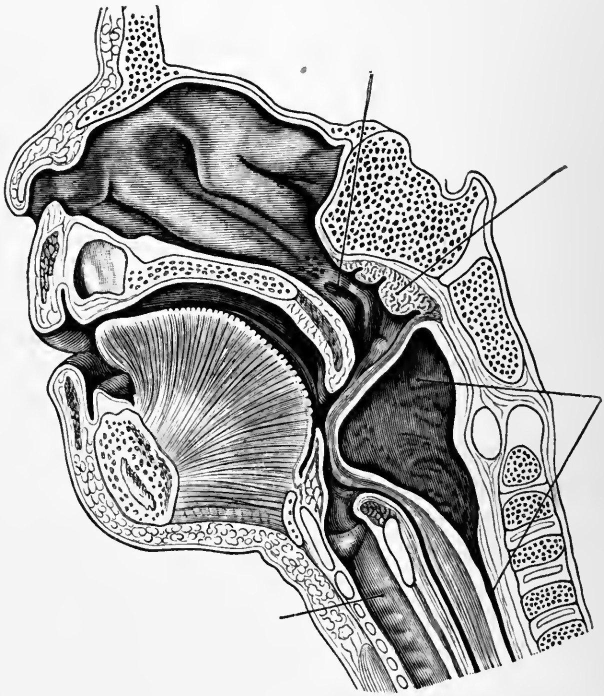


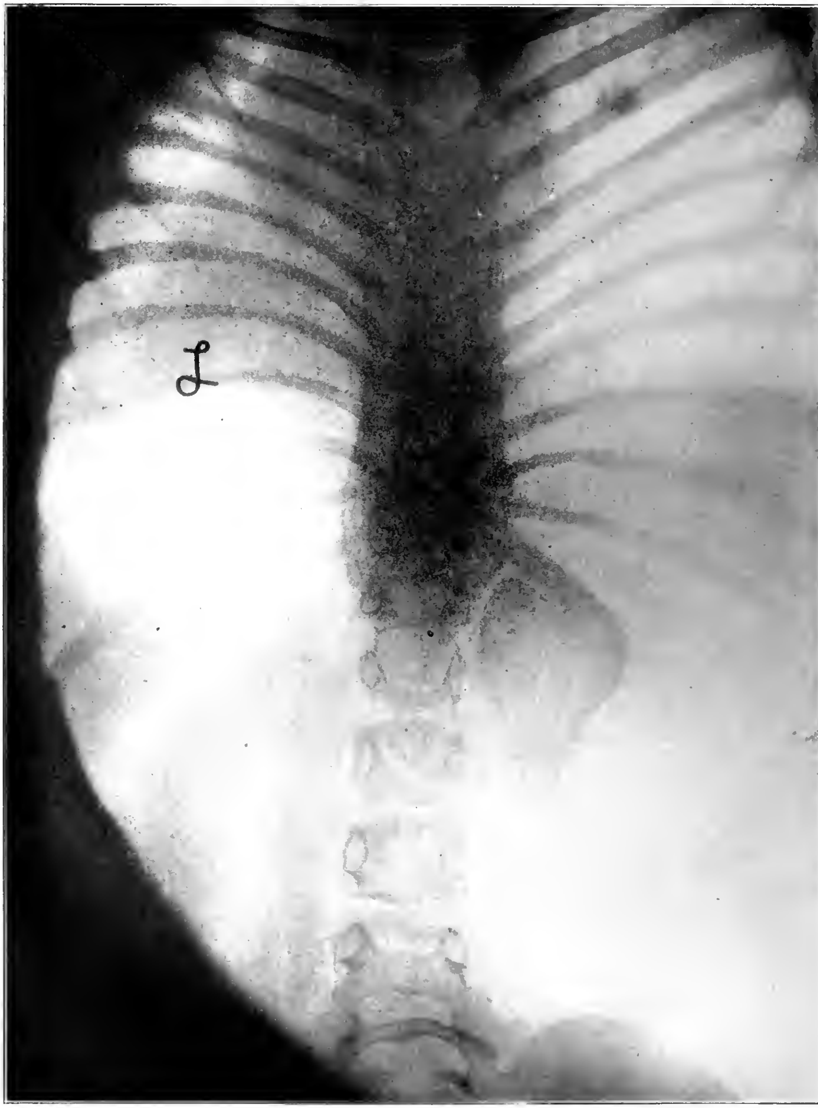
FIG. 50.—A section showing Retro-Pharyngeal Abscess, causing interference with respiration (Wullstein).

sterno-mastoid muscle passes down in front of the thyroid gland and trachea and depressor muscles of the hyoid bone to the great vessels and pericardium. Pus extending beneath this layer has been known to open into the lungs, trachea, and bronchi [1]—notable, but rare events. The præ-vertebral fascia covering the muscles of that name, and separating them from the pharynx and œsophagus, may confine the pus for a time, and then by its increase and the pushing forward of the posterior wall of the pharynx, a retro-pharyngeal abscess arises, causing dyspnœa and dysphagia [2] (Fig. 50).

[1] Cossy, *Bull. Soc. Anat.*, 1877, p. 541 ; and Gamlet, *Bull. Soc. Anat.*, 1878.

[2] Cf. case, Hilton's *Rest and Pain*, 3rd ed. p. 135.

PLATE IV.



Skiagram, taken by Mr. Mackenzie Davidson, of a case of Dorso-Lumbar Caries, under the care of Dr. Ford Anderson and the author, showing the outline and connection with the spine of a psoas abscess on the right side. L. is a wire placed on the left side.

To face page 105.

Occasionally the abscess bursts into the pharyngeal cavity, or opens into the œsophagus, or it may track down into the posterior mediastinum and open through an intercostal space, following the posterior branches of the intercostal arteries. Pus arising from diseased cervical vertebræ frequently passes laterally between the longus colli and scaleni muscles, and opens posteriorly to the sterno-mastoid muscle. Occasionally the abscess bursts directly through the deep fascia, and appears at the sides of the cervical spinous process.

In the Dorsal Region.—Dorsal abscesses are frequently small and sessile. And, further, they have more difficulty in getting to the surface than the cervical and lumbar forms, hence paraplegia is more frequently seen in connection with dorsal disease. The strong fasciæ binding the ribs together largely influence the pointing of the abscess. In the upper and mid-dorsal spine pus may find its way between the posterior ends of the ribs, following the posterior branches of the intercostal arteries, and then gives rise to a dorsal abscess. More rarely does a dorsal abscess encroach on the cavity of the chest (Fig. 51), opening into the pleural cavities, and it may, if large, simulate a tuberculous pleurisy,[1] or an empyema, and may even open into a bronchus or the lung. In lower dorsal and often in mid-dorsal caries, pus gravitates either by the sides of the vertebræ beneath the intercostal fascia, or passes beneath the ligamentum arcuatum internum (Plate IV.). An abscess from the first four dorsal vertebræ is similar in one respect to that from the lower cervical vertebræ, as pus from the former often points in the neck. Likewise suppuration arising in the last two dorsal vertebræ points in the lumbar region.

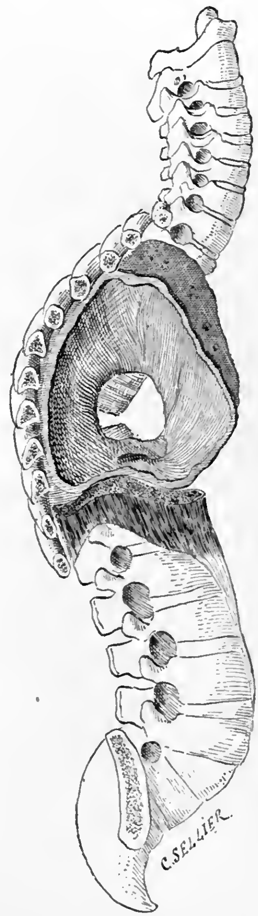


FIG. 51.—A large Dorsal Abscess, which occupied four-fifths of the right side of the thorax (Ménard).

[1] Lüning and Schulthess, *Chir. orth.* p. 354, state that, when such an event occurs, there is an "especial frequency" of meningitis and phthisis pulmonalis.

In fact, the twelfth dorsal vertebra becomes the most important of all, when an abscess forms. Dorsal disease giving rise to lumbar

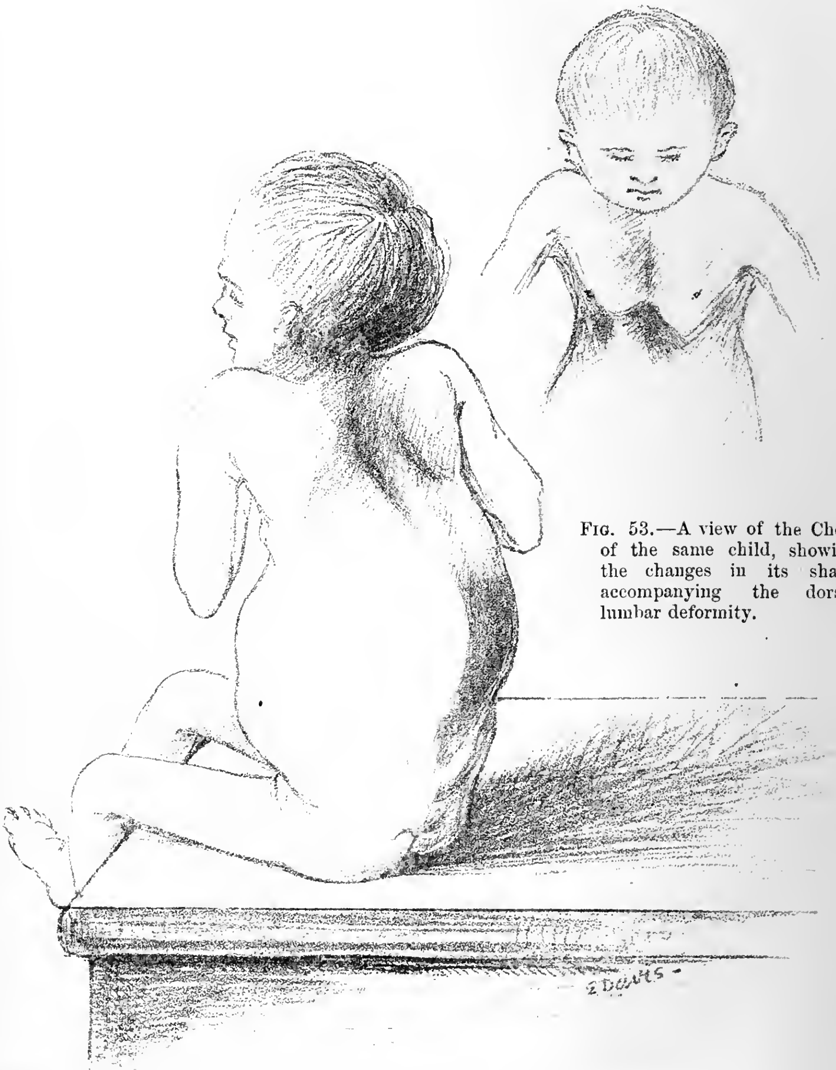


FIG. 53.—A view of the Chest of the same child, showing the changes in its shape accompanying the dorso-lumbar deformity.

FIG. 52.—Advanced Dorso-Lumbar disease, with right Lumbar Abscess (Grace L——, aged 14 months).

or iliac abscess indicates denudation of periosteum spreading downwards.

In the Lumbar Region.—The site of origin of the disease in the bodies of the vertebræ is of importance to the course of the abscess, taking into consideration at the same time the peculiar disposition of the psoas and lumbar fasciæ. The sheath of the psoas muscle is a thin layer, continuous above with the ligamentum arcuatum internum, below with the iliac fascia, behind with the anterior lamella of the lumbar fascia, and it is attached to the bodies of the vertebræ internally.

The lumbar fascia is composed of three layers: the anterior and middle attached to the transverse processes, the posterior to the spinous processes of the vertebræ. The anterior layer is very thin, and offers but slight resistance to an abscess. Pus, following the course of the posterior branches of the lumbar arteries may track through this layer. The middle layer lies between the quadratus lumborum and multifidus spinæ muscles, and gives origin to the transversalis and internal oblique muscles. The posterior layer completes the sheath of the erector spinæ muscle. At the outer edge of the latter structure is a weak spot in the abdominal wall, the triangle of Petit, bounded anteriorly by the posterior edge of the external oblique muscle, and below by the iliac crest. It is in this triangle that lumbar abscesses often point.

If the disease begins in the bodies of the vertebræ (*a*) anteriorly to the attachment of the psoas, or fails to enter the sheath of the psoas, it passes behind the aorta, and thence along the great vessels to the iliac fossa, giving rise to an iliac abscess; it may not stop there, but gravitate into the pelvis, and open by the side of the rectum, simulating a fistula in ano, or passing out of the great sacro-sciatic foramen, form a gluteal abscess (gravitation abscess). Ashby and Wright[1] quote a case of abscess bulging at both sciatic foramina, so that fluctuation could be felt across the cavity of the pelvis. (*b*) If very near or at the attachment of the psoas, it enters the sheath of the psoas, and passing beneath Poupart's ligament, presents either at the inner or outer side of the femoral vessels, or following the course of the internal circumflex vessels, points behind the great trochanter (Figs. 54 and 55); rarely it may present lower down in the limb. (*c*) It often burrows through the anterior and other layers of the lumbar fascia, and appears in Petit's triangle as a lumbar abscess. (*d*) Rarely, it wanders about in the fascial layers till it presents in the anterior abdominal wall. It is this persistent burrowing, the irregularity of the abscess cavity, and the difficulty

[1] *Op. sup. cit.* p. 563.

of ensuring efficient drainage that make dorso-lumbar and lumbar abscesses such serious complications. It is remarkable, however, that pus seldom bursts into the peritoneum, intestines, bladder,[1] or ureter.[2] Very occasionally, it invades the spinal canal and causes sudden paraplegia. In all cases of spinal abscesses, examination *per*

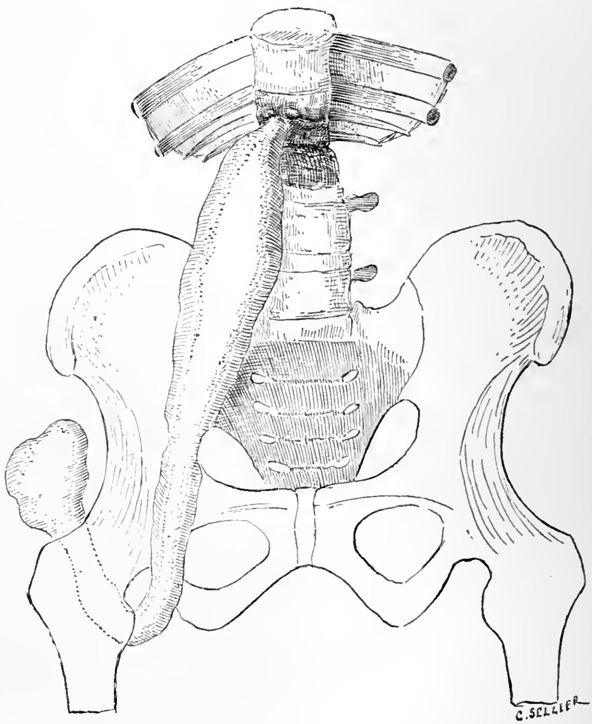


FIG. 54.—A Psoas Abscess, arising from dorso-lumbar disease. The abscess is of the migratory type ; it passed below and behind the neck of the femur and appeared in the gluteal region (Ménard).

rectum should be made to ascertain the presence or absence of pelvic induration.

The *contents* of the abscess vary, but, unless contaminated, are quite free from septic organisms. Sometimes they are serous and

[1] Instances, however, are recorded. If it bursts into the peritoneal cavity a rapid and fatal termination of the case ensues. If into the bladder, so long as the urine remains sweet, the abscess may discharge entirely in this way, and the disease be cured. The possibility of tuberculous infection of the bladder must not be lost sight of.

[2] Cf. a case given by Lannelongue, *Tuberculose vertébrale*, 1888, p. 92.

sero-purulent fluid with caseous masses. In old-standing cases they are often cheesy. In almost all cases minute fragments of carious and necrotic bone are found, but very rarely sequestra of any size. The wall of the abscess is lined with feeble grey granulations ; both they and the pus have highly infective tuberculous properties.

Future Course of the Abscess.—Although absorption of the fluid contents [1] takes place in a few instances,[2] yet this event is too

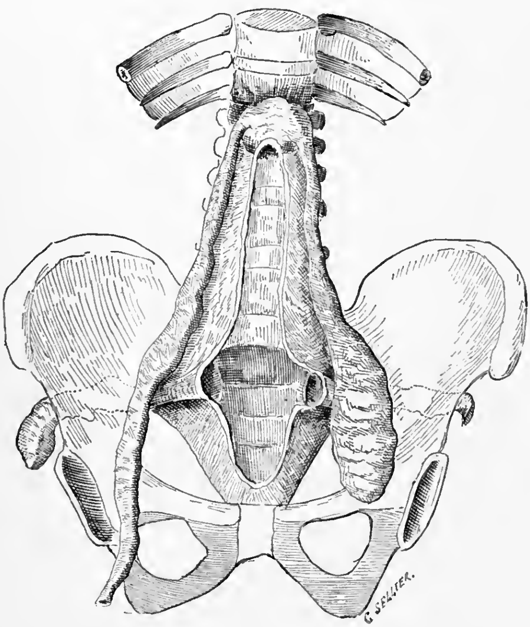


FIG. 55.—Double Spinal Abscess from dorso-lumbar disease. The periosteum is separated from the lumbar vertebræ and the sacrum. On the right side, the abscess is of the psoas, and on the left, of the iliac form (Ménard).

rare to be depended upon, and indeed in many cases it is impossible for the patient to carry out that course of treatment most conducive to absorption, viz. complete recumbency over a very lengthened period. It is quite certain that repose slows the progress, and if dorsal decubitus be initiated early enough, the liability to abscess is diminished. An unopened abscess is sometimes well borne, and

[1] Such residual abscesses are very liable to light up again later.

[2] Ridlon and Jones, *Philad. Amer. Journ.* vol. i. No. 18, p. 777 *et seq.*, state that one-half are absorbed, if the spine is properly protected. They speak very favourably of the results of allowing spinal abscesses to open spontaneously.

it may be discovered only by chance. More often the patient's appearance induces a careful search, and persistent rigidity of the psoas should lead to the suspicion of abscess formation; whilst the increasing pallor, the wasting, and the loss of general health, all point to this undesirable complication. Yet it rarely kills the patient by itself, unless there is excessive periosteal denudation.

An abscess which opens spontaneously, or is opened by surgical measures, in either case without adequate precautions, is likely to be disastrous to the sufferer. Mixed infection follows, septicæmia is indefinitely prolonged, and the patient succumbs from exhaustion or lardaceous disease. Much, however, depends on the length and disposition of the fistulæ. Short fistulæ, as in the cervical region, may be well borne, but an infected sinus in the groin or buttock is a most serious condition. The author is not aware of any successful attempts to render aseptic any such sinus, although assertions to this effect have been made. However, good results have been attained by staphylo- or streptococcic vaccines and by injections of paraffin into the sinus.

When an abscess is carefully aspirated or opened under stringent aseptic precautions, the most difficult part of the treatment has commenced. It is absolutely essential to maintain complete sterility and freedom from pus-producing organisms all through the long and wearisome series of dressings, in fact until the last drop of discharge has ceased to flow; otherwise septic infection follows.

Abscesses may occur on both sides in one and the same patient, and often communicate. In these instances it is best to attack both sides at once, to prevent one leaking into the other.

Paralysis in Vertebral Tuberculosis

Considering the immediate proximity of the spinal cord and nerves to the site of the disease, it is a matter of surprise that this complication does not occur more often. It is equally surprising that so many cases of paralysis treated on the expectant plan of recumbency, with or without extension, recover.

It may be said at once that no very definite relation can be traced between the presence of deformity and nerve-symptoms. On the contrary, the latter may exist without any posterior projection. Nay more, in some cases the signs of bone disease may not be evident until some time after the onset of paraplegia. The fact that the patient is young, and has an inheritance of tubercle will often give rise to a suspicion of caries. Nor is paralysis dependent either on the amount, character, or duration of deformity. It is found with equal frequency in large, medium, and slight projections; it, in some cases, comes on simultaneously with deformity; in others not till months afterwards; in yet others distortion, appearing in early life, is not followed by paralysis until adult life; and in a case which came under the author's observation, fifty-two years elapsed between the onset of caries and that of paraplegia, which was ultimately fatal. This want of relationship is explained by the morbid anatomy of "compression." Very rarely is it due to osseous displacement (cf., however, Figs. 56 and 57). In the majority of cases the active agents are pressure of inflammatory material and pachymeningitis (Fig. 58). Root-symptoms and those of slow compression should invariably lead to a very careful examination of the spine, with a thorough inquiry into the patient's antecedents, especially in the case of children. The formation of a migratory abscess outside the spine often relieves pressure within the canal, either by the breaking down of inflammatory material or by the gradual removal of carious bone. If abscess and paralysis co-exist for any length of time, the prognosis is necessarily very serious, as the disease must be very extensive, and because paralysis indicates osseous or structural compression and not pressure from abscess-tension.

FIG. 56.—Narrowing of the Vertebral Canal by two displaced fragments of bone, derived from the diseased eleventh dorsal vertebra (Ménard).

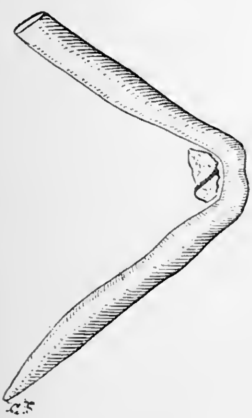


FIG. 57.—The Spinal Cord, as it was seen in the specimen, Fig. 56. The cord is compressed by two displaced fragments of bone, and is narrowed. In addition, tuberculous granulations pressed upon it (Ménard).

In the majority of cases of caries the spinal cord does not suffer.

FIG. 58.—Tuberculous Caries. Nearly complete occlusion of the spinal canal by abscess and granulation tissue (Wullstein).

The reasons are these. Dislocation, although one or more of the bodies may be totally destroyed, is rare. Marked overriding (cf., however, Fig. 59) and the displacement of large sequestra backwards are equally rare. When deformity begins, the anterior part of the spinal column, the bodies, fall together, it is true; but, this falling is due to loss of their substance, so that frequently there is widening of the canal at the affected spot sufficiently great to accommodate not only the cord, but a very considerable amount of inflammatory material and thickened dura mater. Then, too, as the spine is shortened from above downwards, the cord becomes relaxed, and is therefore able more readily to adapt itself to its altered conditions. The cord is gradually curved, not abruptly bent or displaced. Ascending and descending degeneration may, however, set in from "compression."

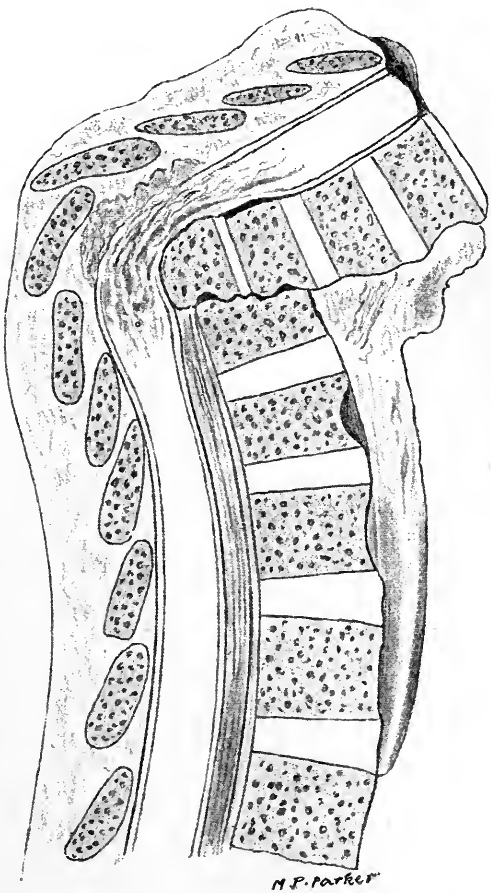


Fig. 59.—Tuberculous Spondylitis. Compression of the cord, partly by displaced bone, and partly by granulation tissue (Guy's Hospital Museum).

The paralysis is usually bilateral; in rare cases it is unilateral. It affects the legs generally, although the arms may suffer later; or both may be paralysed. Sir W. Gowers[1] quotes a case of a child of 3 years, who for two years had presented indications of disease of the cervical vertebræ, and the power of moving the legs was lost in the course of twenty-four hours; during

[1] *Dis. of Nervous System*, 2nd ed. vol. i. p. 247.

the second day the left arm became paralysed, and at the end of a week the right arm. In such instances the cervical vertebræ are necessarily affected, but in the majority of cases the legs alone suffer. Both legs, as a rule, suffer equally. Sir W. Gowers, however, gives a case of unequal affection of the legs.[1]

CASE 3.—*Compression-Paraplegia, Unequal Affection of the Legs.*—"A boy, in childhood, developed angular curvature; at 16 years there was an attack of weakness in the legs, which passed away at the end of three weeks; at 17½ years the patient sprained his back. Pain followed in it; and six weeks later the right leg gradually became weak, and a year and a half later presented intense spastic paralysis, the left leg being very little affected. He ultimately recovered."

Frequently the dorsal cord becomes affected because of the difficulty of the escape of pus arising from a dorsal abscess, and nerve-symptoms arise, especially in disease of the interscapular region where the proportion may rise to 80 per cent. When the disease is above the lumbar enlargement, the condition of the legs is generally spastic, if the destruction of the cord is not excessive.

Dr. T. Halsted Myers[2] has analysed 1570 cases of Pott's disease with reference to the onset of paralysis. Of these 270 were sooner or later paralysed. The site of disease was as follows: 16 in the cervical, 12 in the cervico-dorsal, 105 in the dorsal region above the eighth vertebra, 40 in the lower dorsal, 19 in the dorso-lumbar, 18 in the lumbar, and 9 not stated. The average duration of paralysis in which recovery took place was twelve months in the cervical region, nine and a half in the upper dorsal, six in the lower dorsal, and eight in the lumbar. Eighteen of 218 cases had repeated attacks of paralysis, viz. two had four attacks, and many three attacks with a good recovery; and in two cases the patient passed through two attacks and finally died paraplegic. The average duration of the disease before the onset of paralysis was, in the cervical or upper dorsal region, thirteen months; in the lower dorsal, fifteen; and in the lumbar, eighteen months. The upper extremities were affected in seven cases; of these, three were not treated, three were cured, and one died after operation; of cases affected elsewhere, thirteen recovered without treatment.

We have inserted these statistics on account of their interest, but we think that the proportion of 270 cases of compression-paraplegia in 1570 cases is unusual. That the cases were treated

[1] *Dis. of Nervous System*, 2nd ed. vol. i. p. 248.
[2] *Trans. Amer. Orthop. Assoc.* vol. iii. p. 209 *et seq.*

as out-patients may account for it. If one case in six suffers it means that paraplegia is nearly as frequent as abscess in spondylitis; this is certainly not the case. In mixed in- and out- patient practice the proportion is much less. My colleague, Mr. E. Muirhead Little, has collected from the records of the National Orthopædic Hospital 133 cases, and in only 10 of them was there definite paraplegia. Wullstein, in Joachimsthal's *Chir. Orth.*, states that Döllinger found 41 instances of paralysis in 700 patients affected with tuberculous caries; and Hugelhofer 21 in 215. Oppenheim noted 80 per cent of paralysis in disease of the dorsal region. Generally, Billroth observed nerve symptoms in 14·7 per cent of all cases, Vulpius in 17·8 per cent, and Nebel in 18·5.

FIG. 60.—Very extensive deformity of the Dorsal Spine, with much narrowing of the cord (Guy's Hospital Museum).

Pathological Anatomy of Compression - Paraplegia.—Inflammation in the bodies of the vertebræ extends, and finally causes a perforation of their posterior surfaces, accompanied by a destruction of their periosteum, and of the posterior common ligament. The epidural space, composed of loose fatty or vascular material situated immediately behind the ligament, is next invaded by the tuberculous material, either in the form of granulation material or abscess, but is rarely obliterated by displaced bone (cf., however, Fig. 60). So that, practically, in most cases a peri-meningitis arises, which is followed later by a pachymeningitis. The spinal cord suffers slow compression, being flattened or constricted and narrowed by the pressure of granulation tissue or pus,[1] and becomes œdematous; in the neighbourhood

[1] Lannelongue's experiments as to the intra-abscess pressure are interesting, and illustrates the effects of the pressure of pus in the spinal cord. He found that the intra-abscess pressure was 17 mm. of mercury.

of the compression, softening of the cord occurs, with myelitis. This is accompanied by destruction of the myelin sheaths of the nerves and by increase of the neuroglia; sclerosis ensues with partial or entire destruction of the nerve elements and ascending and descending degeneration. At the same time, too, or even before this, the nerve-roots suffer from pressure and exudation of new material around them.[1] They may be seen to be red and swollen, or grey and wasted, and even reduced to fibrous cords.

The spinal cord may be indented or flattened, as above mentioned, or cylindrical, and much reduced in size. It has even been found as small as a crowquill.[2] Much narrowing of the cord is not incompatible with recession of the paraplegia, and in some cases the cord has been found considerably narrowed, when the patient has died from some other cause. In a case of compression-paraplegia at the National Orthopædic Hospital, on which I operated, the spinal cord was so much compressed by the arch of the tenth dorsal vertebra that it was impossible to pass a fine probe between the bone and the cord. It was necessary to pick the bone away with a pair of fine bone forceps. In another case at the Evelina Hospital, when I removed the arch of the fifth dorsal vertebra the cord and meninges above were so compressed that they projected like a shelf from a wall.

To sum up, the following conditions account for the symptoms :—

A. *Inflammatory.*—1. The pressure of granulation tissue and particularly of intra-spinal abscess. This is proved by post-mortem examination in which patients with compression paraplegia have died unrelieved, and the cord has been found compressed by an abscess. It is a common observation, that the appearance of an abscess outside the spinal canal in a paraplegic case is accompanied by relief from the pressure symptoms. Again, if an abscess in the canal be evacuated either by costo-transversectomy or by laminectomy, the paraplegic symptoms disappear. Laminectomy without evacuation of an abscess is frequently an unsuccessful operation. 2. Peri-pachymeningitis and pachymeningitis are certainly the sole causes in some cases, especially when many nerve-roots are

[1] For the description of the microscopical changes in the cord and nerves, standard works on "Diseases of the Nervous System" should be consulted. Cf. Gowers and Taylor, *Diseases of the Nervous System*, 3rd ed. vol. i. pp. 286 *et seq.* "Caries of the Spine,' and p. 390, *et seq.* "Compression of the Spinal Cord."

[2] Cf. Ménard, *op. cit.* p. 139, who gives an illustration of the section of the spinal cord at the site of compression. Gowers and Taylor also figure such a case, *op. cit.* p. 391.

involved. It must be said that Ménard, an excellent authority on this subject, does not agree with this view. 3. Involvement of the nerve-roots in granulation tissue with peri-pachymeningitis. If several nerve-roots are affected, pachymeningitis has extended for some distance over the cord. 4. Medullary changes consecutive to pressure. These consist of softening from anæmia following pressure on afferent vessels (Ziegler), œdema from pressure on efferent vessels (Kahler), or perhaps œdema from circulation of bacillary ptomaines, and in excessively rare instances tuberculous myelitis.

B. *Mechanical.*—By dislocation and overriding of the spinal segments, by displacement of sequestra backwards, or by mere inflexion of the cord upon itself (Ollivier). All these causes are infrequent. Immediate compression of the cord is very rarely due to extravasation of blood after an incautious movement, sufficient to rupture a blood-vessel.[1]

Symptoms of Compression-Paraplegia.—They vary, necessarily, with the site of disease, the rapidity and degree of the pressure, the amount of myelitis produced, and the number of nerve-roots involved. The *onset* is in some cases very sudden, and is due then to displaced bone, rupture of a blood-vessel, acute myelitis, or tuberculous meningitis. As exemplifying rapid loss of functions Gowers mentions several cases. In one of them, a child of 3 years of age, slight weakness existed for three weeks, and then the power of standing was lost in a single night. More often paralysis is gradual, and not without warning in the form of slight paresis and radiating pains, and exaggerated patellar reflexes.

Several of the salient points in the history are illustrated by the following case, which came under my care:—

CASE 4. *Compression-Paraplegia, Gradual Recovery during Recumbency.*—J. H. F., aged 5 years, was admitted on 5th January 1892. The back had "grown out" two and a half years previously, and the child had lately become "weak on its legs." Beyond these details the mother could give no information. On admission, the child was pale and weak, and entirely unable to walk. There was a large posterior curvature in the dorsal region, extending from the seventh dorsal to the first lumbar vertebra. The projection was rounded. Partial anæsthesia was

[1] Such an event may have occurred in one of Sir W. Gowers' cases:—"A woman, aged 45, who had suffered from pain in the spine, one day, whilst walking, sneezed violently three times, and immediately felt 'pins and needles' in the right knee, and subsequently in the foot. The right leg became powerless during the next three days, the left leg followed suit, and at the end of six weeks both legs were motionless." She died six months later.

present from the ninth rib downwards on both sides, but sensation to painful impressions was still retained; he felt slightly the forcible prick of a pin; as he lay in bed the legs were extended and rigid, with considerable adductor spasm and muscular wasting. He could move the legs slightly, making some attempts at flexion and rotation. The knee reflexes were present and exaggerated. There was some incontinence of fæces when the motions were loose, and imperfect control over the bladder; at night he passed urine in his sleep; and in the daytime he had to relieve himself directly he felt the desire. Temperature was 98°·4 F., and no abnormal signs were found in the chest. The child was placed in bed with an extension-collar beneath the chin and occiput, and the head of the bed raised three inches. It was noted, on raising the child into the sitting position, placing one hand over the lower part of the sternum, and pressing with the other firmly over the prominence behind, that there was considerable yielding forwards in the spinal column ("pressure with the palm of the hand" test).

26th January.—The spine was more consolidated, but there was no improvement in the bladder symptoms, nor in muscular power.

11th February.—He was now sensitive to touch in both legs.

16th March.—Could flex knees and ankles freely, and raise the legs two inches from the bed. The fæces were easily retained, and the urine did not escape so freely.

1st June.—He attempted to raise himself in bed, the adductor spasm had completely disappeared; he held his water well, and kicked his legs about in the bed with freedom. The spinal column had increased in firmness, and the child was fatter.

28th September.—He could walk a few tottering steps without support, and the back was quite firm.

6th December.—He was quite able to walk alone. He was discharged wearing a poroplastic jacket with a head-support, and the extension apparatus to be used at night at home.

Sir William Gowers[1] ascribes the nerve-symptoms to two causes:—(1) Due to involvement of the nerve-roots at the level of the morbid process, (2) arising from interference with the functions of the cord itself.

Root-symptoms are pain and hyperæsthesia. The situation of the pains varies with the position of the roots affected, and in character they are sharp and twinging. Hyperæsthesia, often associated with anæsthesia, "anæsthesia dolorosa," is found in irregular areas. Muscular wasting and reaction of degeneration follow later.

To these are added symptoms of involvement and partial or entire loss of the function of the cord. Such are—

(*a*) Motor.—The patient complains of getting tired easily, and soon the legs begin to drag, and the toes to catch in walking. With

[1] *Dis. of the Nervous System*, 3rd ed. vol. i. p. 393.

these signs there are loss of equilibrium and complete inability to stand alone, since both legs usually suffer equally; and, finally, the child lies in bed, quite unable to move the lower extremities. If the disease is in the cervical region, the arms suffer before the legs. Occasionally it happens that in occipito-atlantal disease the diaphragm is paralysed, sometimes suddenly; also the spinal accessory and hypoglossal nerves are affected.

(*b*) Sensory.—Dull aching pain is common in the early stages, both in the body and limbs. In the body, the most usual form is "girdle-pain," and in the legs sharp twinging pains, whilst tingling and formication are complained of. Sensation is frequently regained when motion remains absent, and this is often the earliest sign of improvement in an obstinate case.

(*c*) Reflexes.—The superficial reflexes are exaggerated, and so too are the deep, especially the knee and ankle. If the lumbar enlargement is involved, the reflexes are absent. When degeneration has set in, they are lost as in disease in other regions of the cord.

(*d*) Sphincters.—Incontinence of urine and fæces occur in severe cases; but I do not share the opinion that they indicate any excessive gravity or inability to recover.

(*e*) Trophic.—The affected muscles waste, and the "reaction of degeneration" is more or less marked. Before wasting sets in, distinct spasm of muscle is found, notably when the disease is in the dorsal cord. Herpes zoster has been seen along the course of the irritated nerves (Gowers). Acute bed-sores are not uncommon. Arthropathies of medullary origin are seen in the hips, knees, and ankles. They are characterised by simple effusion and last two to three weeks.

(*f*) Vaso-motor.—The limbs are often cold, and sometimes perspire persistently.[1]

(*g*) Special to various regions.—In the cervical region the pupil may be dilated; in the dorsal the intercostal muscles are affected; hence with diminution of breathing capacity and horizontal decubitus, acute bronchitis and broncho-pneumonia become serious complications.

Diagnosis.—The pain of compression has been referred to all manner of causes, but it avails little to tabulate these. Suffice it to say that it should be an invariable rule to examine carefully the back, if any of the above signs, more especially root, symptoms, are

[1] Gowers has seen persistent sweating of one-half of the forehead in cervical caries, due to interference with the cilio-spinal centre.

present, and this is the more urgent if we are dealing with a child whose history is tuberculous. Although a projection may be absent this should not negative the existence of Pott's disease. It has happened that the paraplegia has disappeared when a projection has formed. As stated above, the nerve symptoms may declare themselves before the bone symptoms. The practical deduction is, examine a child back and front, and so avoid the vexation of having the cause of the paralysis pointed out by a more discriminating surgeon.

Prognosis.—The majority of cases recover without operation. Recumbency with extension is often sufficient to induce an immediate change for the better, and effects a cure in at least 83 per cent. In fact, there is no organic nerve-lesion so amenable to simple measures, and so hopeful in its treatment. Some cases, as mentioned previously, recover without any form of treatment. Recurrent attacks are dangerous, but not so *per se.* Cystitis and bronchitis are grave complications, but we have known some such cases recover, and the presence of these troubles should not urge one to hasty operation. Many patients, however, die from trophic ulcerations with suppuration, and others from cystitis and surgical kidney. The value of laminectomy will be dealt with under the general heading of treatment.

To complete the list of the complications of Pott's disease, we may mention localised pleurisy, due to direct extension of the morbid process from the vertebræ, and mediastinal abscess. A general condition of asthenia from the caries itself occurs, in which, however, the reflexes are normal, so determining the absence of true paraplegia. Digestive disturbances are not infrequent, and *crises gastriques* occur.[1] At any time acute tuberculosis in one clinical form or another may arise.

Trophic ulcerations with septic suppuration and surgical kidneys are frequently the causes of a fatal termination.

Diagnosis of Spinal Tuberculosis

In forming an opinion as to the causation of symptoms referable to the spine, we are accustomed to rely chiefly upon pain and limitation of movement, with rigidity of muscle and of the articulations. Radiography early in the disease is usually of little use, and merely tells us what we know already. However, it is of great assistance later.

[1] Cf. also the persistent and dangerous attack of vomiting associated with infantile paralysis, due perhaps to acetonæmia.

In vertebral tuberculosis, pain may be absent at first. As a rule it is present, and is usually of the reflected variety. It should be remembered that reflected pains are of greater value than local from a diagnostic view. Rigidity of the muscles is, in exceptional instances, of short duration, and may therefore escape observation, but it is always present at some stage of the disease.

When the angular deformity is pronounced, no doubt whatever can arise, but in the earlier stages it is possible either to overlook or totally mistake the condition. Experienced surgeons have frequently been at fault, owing to the peculiar complexity of symptoms in an individual case. Gibney quotes a case in which the malady was first thought to be a sprain, and five months later to be a subacute dorso-lumbar meningitis or a coxal neurosis; two years later it was pronounced to be lumbar caries with psoas abscess, and at the time of writing the diagnosis was doubtful. Reeves,[1] quoting this case of Gibney's, says, "I mention this case to show not only that the symptoms may be obscure, but that they will vary according to the stage of disease causing it." Herein lies the whole truth. Symptoms may be tabulated and general rules given, but cases are seen which conform to no rules and no particular type whatsoever. Wullstein [2] alludes to a case of Pott's deformity, diagnosed and treated as typical tuberculous caries, which at the post-mortem was found to be sarcoma.

In infancy and early childhood *rachitic kyphosis* is common; but the general yielding of the back as a whole, the absence of localised pain, the evenness of the curve and its disappearance on suspension or lying down, and the full amount of hyperextension to nearly 90° obtainable in the prone position, when the legs are lifted off the couch by the surgeon, together with the presence of other signs of rickets, are sufficient points of distinction.[3] In young adult life, especially in girls and young women, occasionally in neurotic boys, and in men notably after railway accidents, we find the *hysterical* or *neuro-mimetic spine*.[4] Hence there is much pain and not seldom stiffness. Nevertheless, it should be noticed that the pain is "patchy," not following the course of nerves, but limited to certain localised areas, with more than one point of special intensity;

[1] *Bodily Deformities*, p. 138.

[2] Joachimsthal, *Chir. orth.* Pt. II. pp. 1327, 1328, 1329.

[3] In very severe rickets I have, however, seen so sharp an angle produced in the dorso-lumbar region as to cause grave doubt whether the case was one of rickets or one of caries.

[4] Sir J. Paget, *Clinical Lect. and Essays*, Lecture v.

it is superficial as well as deep, and may change its seat. There are also spots of anæsthesia. Gowers[1] says, "There is more danger that caries of the spine in a young woman may be passed as hysterical paraplegia than of the opposite error. Especially, when the subjects of caries present distinct symptoms of hysteria, there is risk, as experience shows, that unequivocal signs of caries may be overlooked." Unsuspected watching of the case, and careful and repeated examination of the back are necessary. In any case let the surgeon beware lest he let the words "spinal disease" slip lightly from his lips when seeing neurotic women, if the symptoms appear doubtful at first sight. In those past middle life a natural or *senile kyphosis* sets in. As previously stated, the onset of Pott's disease is unusual after middle life, still it has been recorded several times. *Syphilitic* curvature will be dealt with later.

The diagnosis from *scoliosis* or *lateral curvature* is generally easy; the presence of marked rotation from the first, the absence of rigidity and pain, are sufficient points of distinction. Lateral deviation with some angular deformity is not uncommon in Pott's disease (Fig. 43, p. 94). Dr. Bernard Bartow has written an admirable and well-illustrated article on this subject,[2] although I am unable to agree with him as to the frequency of rotation. That such, however, may occur is well shown by the following case, Fig. 43, p. 94:—

CASE 5.—*Pott's Disease with Deviation and Rotation.*—Alfred K——, aged 10 years, was seen by me at the Evelina Hospital in April 1894 on account of a projection in the back and pain. Four years ago he fell across the rail of a bedstead, and experienced considerable pain at once. The next day he was taken to St. Bartholomew's Hospital, and some liniment was applied. He lost the pain and was able to get about well until within the last few weeks, when he began to suffer, and was noticed to be walking unevenly.

On examination, there was a posterior projection extending from the eleventh dorsal to the second lumbar vertebra. The summit of the projection was deviated a half to one inch from the middle line. The lumbar curve below the projection was flattened, while above the prominence a distinct lateral deviation to the right was seen, embracing the whole dorsal region, and best marked from the ninth dorsal vertebra to the site of disease. The right scapula and ribs were prominent. There was no compensatory curve above. The attitude was erect and military, there was rigidity of the right erector spinæ muscle, and he was unable to touch his toes with the knees extended. Pain was felt in

[1] *Op. sup. cit.* p. 252.

[2] *Annals of Surgery*, vol. x. p. 48.

the course of the first, second, and third left lumbar nerves, but no "girdle pain" was present, nor paralysis of the lower limbs. Distinct thickening about the lumbar vertebræ was felt. He slept well, but could not turn in bed on account of the pain. There was no history of phthisis in the family, and no signs of phthisis were found in the patient. A plaster of Paris jacket was applied, and the boy lost the pain and was able to get about well.

Lovett,[1] writing on this subject, sums up as follows:—

1. "Lateral deviation is common, especially in advancing cases, but absent in those getting well and those cured; the early cause is muscular irritation, the later, unilateral absorption of bone. 2. Rotation is not a prominent factor. 3. The distortion is not that of scoliosis, viz. a sinuous curvature, but a distinct leaning of the body from one side to the other.[2] 4. The deformity of the chest in lateral deviation from Pott's disease does not follow the same rule in scoliosis; in the latter, the ribs rotate backwards on the convex side, in caries on the concave side; cervical cases show the least lateral deformity. 5. With the onset of marked lateral deviation a great increase of all the symptoms occurs, and pain is much greater on one side than before, but disappears with the diminution of the deviation under treatment." 6. Bartow especially notes that the patient is unable to overcome the distortion by any effort of his muscles that he is able to exert. 7. Another feature of the deformity is its reluctance to yield, except in a slight degree, to extension-force applied, whilst the patient is in the erect position.

As a rule it may be said that other signs of Pott's disease are present and suffice to clear up the diagnosis. That the matter is not so simple as it may appear at first sight is shown by Fig. 43, p. 94, and Fig. 61, p. 124. In both cases there is a limited projection of the lumbar spines, in both there is lateral deviation, in both, pain; but in Fig. 43, the boy with Pott's disease, there were present the "tell-tale" rigidity below the prominent spine and the local thickening; whilst in the girl (Fig. 61) these were absent.

Curvature in some cases is due to *syphilitic disease*. It occurs in adults often more than in children, and affects the upper part of the column rather than the lower. The only clue to the cause of the deformity is the presence of other syphilitic symptoms.[3] *Malignant disease* of the spine simulates caries in some instances.

[1] *Trans. Am. Orth. Assoc.* vol. iii. p. 182.

[2] The upper part of the body in those cases I have seen appears to be sliding off the lower, at the affected spot.

[3] The Wassermann test may help to clear up the diagnosis.

Malignant disease of the spine is usually secondary, very rarely it is primary. Pain, often amounting to agony, is the chief symptom, and it may be present from the first. The progress of the disease is rapid; deformity, paralysis, incontinence of urine and fæces, and bed-sores make their appearance early, also cachexia. Rapid loss of flesh, with no signs of improvement on recumbency, are characteristic.

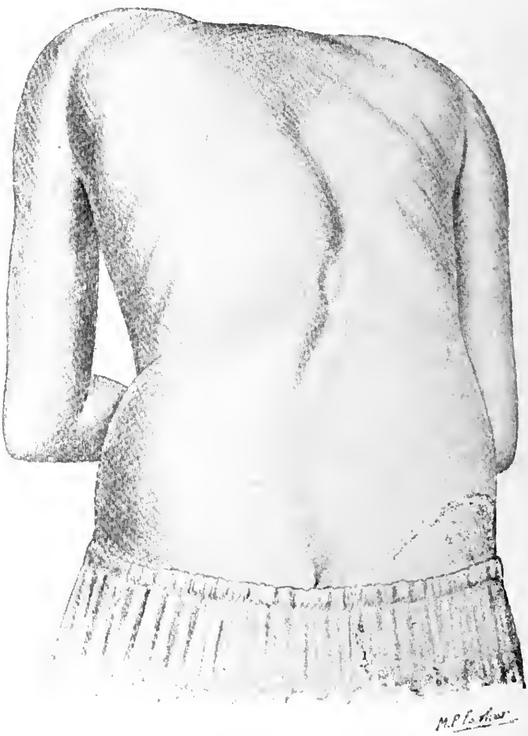


FIG. 61.—Lateral Curvature of the Spine, with marked prominence of two spinous processes.

In malignant disease of the spine, when a projection is found, it is usually more rounded and less sharp than in caries; and a "malignant" projection does not carry on it a bursa. It is too rapidly formed. In complicated cases, however, the utmost difficulty arises, and the diagnosis is often conjectural. I was asked to see a lady who had one of the breasts removed for carcinoma three years previously. When I saw her, she complained of continuous pain in the back, on which was a rounded posterior projection in the dorsal region. In addition she had symptoms of osteo-arthritis in the right knee and shoulders. The diagnosis lay between malignant spine and osteo-arthritis. Lapse of time can alone clear up the case, and it is now only two months since I saw her.

In cervical caries the head, as previously mentioned, is displaced to one side, and may be confounded with *wry-neck*. Fortunately for the diagnosis, considerable thickening of the soft tissues occurs early in cervical disease, and the back of the neck is flattened. In true wry-neck the head is rotated to the opposite side, though drawn down to the shoulder on the affected side; and the face and head are asymmetrical. The face on the affected side is smaller than the other, and the eyes are not in the same plane.[1] In displacement from caries the head is fixed laterally, but is not rotated; and the deep muscles as well as the sterno-mastoid are contracted. Movement is very limited or absent in caries, whereas in wry-neck it is free in all other directions save when the shortened sterno-mastoid is pulled on. Then, too, there are the anxious expression, and the attitude and "military" movements in caries; and in more advanced cases the head is held with the hand supporting the chin. Rheumatic torticollis cannot at first be differentiated from caries.

Hip-disease or coxitis may mislead, unless careful examination be made. The contraction at the joint and the flexion simulate the psoas-contraction of spinal disease, but recognition of the limitation of all the movements at the hip-joint in coxitis, especially of flexion, will generally serve to clear up doubts, although in rare instances of caries the limitation of the hip-movements is in all directions; and again in hip-disease the lumbar spine is sometimes rigid. In rare instances coxitis and caries co-exist.

CASE 6.—*Co-existence of Spinal Caries with Double Coxitis.*—W. B., aged 9, when 3 years old attended Great Ormond Street for double hip-joint disease, and weight-extension was applied. The joints ankylosed, and he afterwards went to the Convalescent Home at Highgate, where he stayed a considerable time. A year ago the mother noticed a projection in the back. I saw him at the National Orthopædic Hospital. His appearance then was striking; he had the bowed aspect of advanced age; in the back a projection was seen, composed of the spines and

[1] Whilst these remarks are true of anterior wry-neck, considerable difficulty arises in cases of posterior torticollis, where the deeper muscles are involved, and movement is limited by a general muscular resistance. The best test is to place the patient for a few days in bed and see if extension of the head overcomes the distortion, as it will if the case is one of early Pott's disease. Bradford and Lovett (*Orth. Surg.* 2nd ed. p. 32 *et seq.*) state that they know of cases in which the diagnosis was impossible, and of some in which, on account of the difficulties presented, tenotomy had been performed for what proved to be Pott's disease.

transverse processes of the eighth to the eleventh dorsal vertebræ. Both hips were firmly ankylosed, the right at an angle of 30° and the left at an angle of 35°. On examining the spine it was found to be very yielding over the projection, and there was very marked girdle pain, also much general distress and illness. A poroplastic jacket was fitted, cod-liver oil ordered, and the mother advised to get him away to the seaside. The case ultimately did well, but very considerable deformity ensued.

From *sprains* of the back the immediate diagnosis is often impossible, and an opinion should be given with the greatest reserve in children. In many cases the trauma is succeeded in two or three months' time by signs of Pott's disease.[1]

From *sacro-iliac disease* the diagnosis is made by the absence of rigidity in the spine, the persistence of pain over the affected joint, the characteristic "sacro-iliac" attitude and the apparent lengthening of one side of the lower part of the body, due to weakening or destruction of the sacro-iliac ligaments. As the disease progresses, swelling appears over the joint, followed by fluctuation. The latter must not be mistaken for spinal abscess.

Osteo-arthritis and *osteitis deformans* cause a general and not a limited kyphosis; they do not give rise to reflected pain, unless it may happen—a rare event, I believe—that the nerves are pressed upon as they issue from the spinal canal.

Perinephritis and *perityphlitis*, in addition to pain, have one symptom in common with dorso-lumbar and lumbar caries—psoas-contraction. A careful examination of the urine must be made, and radiograms taken to determine the existence of a calculus.[2] *Erosion of the spine from aneurism,* although it gives rise to dry caries, can scarcely be mistaken for Pott's disease in the ordinary acceptation of the term. Long before any deformity can occur, other symptoms, sufficient in themselves to render evident the cause of the persistent pain in the back, are present.

[1] Many such cases are on record. Verneuil (*Bull. Acad. méd.*, Sept. 27, 1892) quotes the cases of a man aged 49 years who fell on ice, and a prominence appeared eighteen months after; also that of a boy, aged 17 years, who fell on his back and developed spinal disease in three months. Cf. also Henle, *Archiv f. klin. Chir.*, Bd. 52, Heft 1, and Kirmisson, *Rev. d'orthop.*, 1896, p. 481; and further, the case of a man, aged 60 years, who came under our observation at the National Orthopædic Hospital, who was thrown against the tail-board of a cart, and developed spinal caries.

[2] In the case of a girl aged 18 years, who came under my care, I was misled by a radiogram. She had pain in the left lumbar region, which was so considerable that she was bent nearly double. The radiogram showed a dark shadow, which was thought to be due to a calculus in the ureter. An exploratory operation was performed, but no calculus was found. Four weeks afterwards rigidity and prominence of the 12th dorsal and 1st lumbar vertebræ were discovered. The shadow in the radiogram was due to a calcareous lumbar gland.

Other conditions confused with spinal tuberculosis are acute and chronic rheumatism, acute osteomyelitis, the typhoid spine, gonorrhœal spondylitis, and traumatic affections of the spine. In all these instances the family history, and that of the patient, must be carefully inquired into, and one of the golden rules of diagnosis must be observed, viz. to examine the patient all over, and particularly the tissues and structures throughout the body, similar in nature to those to which attention has been drawn, and on which an opinion is being sought.

With regard to the *diagnosis of the cause of the paraplegia*, in some instances it precedes deformity, but rigidity and other symptoms of caries are present from the first. As to the other causes of paraplegia, such as myelitis, meningeal tumours, gummata of the cord, the reader is referred to standard works on "Diseases of the Nervous System."

The *advent of abscess in caries* sometimes complicates the diagnostic problem. Renal symptoms may occur from abscesses which are spinal in origin. Mr. Jacobson, writing on the subject of nephro-lithotomy,[1] says, "The great difficulty which may arise in diagnosing between certain cases of spinal caries and renal calculus is not yet sufficiently recognised. G. A. Wright[2] thus alludes to this matter: 'When a local patch of caries of a vertebral body exists, and especially where deep suppuration occurs and presses upon the kidney, as in a case of my own and one or two others which I have seen, nearly all the symptoms of a calculus have been present. In my own case, without any deformity or tenderness of the spine, there was unilateral rigidity, testicular pain, intermission of symptoms, increased frequency of micturition, nausea during the attacks, and oxaluria with local pain and tenderness. Subsequently an abscess developed; and on exploration, a small patch of caries was found, and the kidney was felt exposed on the anterior wall of the abscess cavity. Probably, as in floating kidney, obstruction of the vessels and ureter may arise and cause symptoms, so that pressure of the spinal abscess may disturb the kidney, and quite possibly give rise to hæmaturia.'" Erichsen[3] says: "I have, however, seen an abscess dependent on caries of the vertebræ not only assume the perinephritic form, but open into the pelvis of the kidney, thus simulating chronic pyelitis. In this case the diagnosis was made by a careful examination of the pus, in which molecular

[1] *Brit. Med. Journal*, 1890, vol. i. p. 117. [2] *Med. Chron.* No. 6, p. 642.
[3] *Science and Art of Surg.* 8th ed. vol. ii. p. 426.

masses of carious bone were found. The chemical and microscopical examination of the pus in all cases of doubt should never be omitted."

As psoas abscess in the vast majority of cases presents in the thigh, and numerous other fluid swellings are also found there, it behoves the surgeon to attend carefully to the diagnosis of these swellings. They may be appendicular abscess; iliac abscess arising from disease of the pelvic bones; localised collections of pus in the muscular and areolar tissue; intra-pelvic abscess arising from coxitis; cysts; femoral hernia with fluid in the sac; and bursitis. As Sir John Erichsen pointed out, if the iliac abscess is superficial to the fascia iliaca, as in an appendicular abscess, it very rarely passes beneath Poupart's ligament, owing to the firm attachment of these structures. When a collection of pus forms beneath the fascia iliaca, there is nothing to prevent it extending to the psoas and passing down under Poupart's ligament; and the determination of its origin, whether from disease of the ilium or vertebræ, or from a hæmatoma, can only be made by the presence or absence of the symptoms of disease of the spine. Psoas abscess also in many cases appears suddenly in the thigh, the patient on washing himself in the morning finds that he has a large soft tumour in the groin; whereas iliac abscess comes on more gradually, and presents in a more diffused manner.

From *femoral hernia* the diagnosis of abscess is not difficult; both give an impulse on coughing, but the gurgling on the return of a hernia and its sudden reappearance when the pressure is taken off are characteristic.

The Prognosis of Vertebral Tuberculosis

The incidence of tuberculous caries is necessarily of serious import to the general health and life of a patient. The severity of the disease itself; the part affected, the spine being the central axis of the trunk; the effect of even uncomplicated caries on the general health; the probability of severe complications, such as abscesses with all their attendant train of evils; the danger of paralysis; the possibility in tuberculous cases of the existence of foci elsewhere,—must all militate severely against the attainment of longevity; and for years, in any case, the patient's health is enfeebled. The outlook, however, is not so serious in all cases. Many patients recover entirely, and may be seen to acquire fresh strength and health after the disease has passed away. They may even become vigorous old men in spite of the deformity, just as many sickly children, carefully reared in their earlier years, survive the wear and tear of early and middle life, and preserve their strength, even in declining years. At the sea-coast and in healthy country districts an old man, hale though deformed, is not such a rare phenomenon to the medical man as might be expected by those whose practice lies in towns.

In the first place, let us consider the prognosis in *uncomplicated* cases when seen for the first time by the surgeon. The factors to be considered are the family history, the age, the condition of the spine, and the social status of the patient. We may then pass on to discuss the elements of prognosis as to duration of the disease and, the probability of recovery. Having spoken of simple cases, it remains then to speak of the probable results of abscess, paralysis, and visceral lesions.

Family History.—In a simple uncomplicated case with or without deformity, in which there is no history of tuberculosis in the parents or grandparents, a favourable opinion may be expressed as to the ultimate cure of the disease under suitable conditions of treatment. Much deformity may follow, but the patient may lead a useful life. To quote an example:—

CASE 7.—*Pott's Disease after Injury; Complete Recovery.*—A. G., aged 50, when 9 years old, climbed up the rain-water pipe on the side of a house, and fell from a height of fifteen feet. He injured his back severely, and considerable pain followed. This was succeeded in four months by the appearance of a projection limited to the upper dorsal region. Notwithstanding the pain, the child was allowed to get about, and the deformity then became much greater. Subsequently, however, complete cure without abscess followed, and the patient became healtht and strong, and able to enter into all the duties of active life. His greay grandfather attained the age of 78, his grandfather 93, his grandmother 85; his father is alive aged 75, and his mother recently died aged 77. Other members of his family are well and strong. Since the above was written in 1896, the patient in 1904 developed acute paraplegia, and died after six months' illness.

On the other hand, a tuberculous family history is almost always, if not entirely, an unfavourable element, and minimises the prospect of complete recovery, whilst it increases the probability of extensive disease of bone, abscess and the development of tubercle, visceral or arthritic, under the prolonged strain of the disease itself, and the tedious course of treatment necessary.

The Age.—In children the prognosis is less favourable than in adults, because phthisis is much more likely to develop in the former than in the latter, and the opinion as to cure of the disease and the length of treatment must be more guarded on account of the more extensive bone-destruction. The co-existence of tuberculosis of the spine, hip, knee, elbow, or wrist, but very seldom of tuberculous dactylitis, is not uncommon. Usually these diseases precede Pott's disease; the reverse event is rare. Ménard finds Pott's disease, when associated with tuberculosis of big joints, less unfavourable, than when tuberculosis of several small joints exists. And as a generalisation on tuberculosis, Ménard (*op. cit.* p. 299) says that if a tuberculous focus appears on the cranium it indicates a marked skeletal predisposition to tuberculosis, and is often followed by outbreaks elsewhere.

In a careful article[1] on Pott's disease and pregnancy, Dr. T. Halsted Myers points out that the gravity of the prognosis is much accentuated by *pregnancy*, even when the caries is apparently cured. The weight of the gravid uterus, in active disease, increases the probability of abscess-formation, especially when the disease is lumbar. If the disease be entirely cured, the disturbance of the circulation induced by pregnancy tells upon the heart, and some patients succumb from cardiac failure.[2] Dr. Myers quotes seven cases in which active disease complicated pregnancy. Four were dorsal and three dorso-lumbar. In six of them, pregnancy greatly increased the severity of the disease. In the remaining case, pregnancy and parturition were harmless.

The Condition of the Spine.—The following points should be carefully observed: the amount of rigidity, the number of vertebræ affected, the yielding state of the spine, the size of the projection, and the number of foci of disease. They will serve as guides in forming the basis of an opinion. Disease is always very serious in the dorsal region, and as a rule not less than three vertebræ are affected; whilst the whole region may be involved and the deformity is enormous. Dorsal disease always gives rise to a great amount of danger and much deformity. In the lumbar region the destruction is rarely so extensive as in the dorsal, and even in the absence of all treatment, the deformity is not very marked. The former cases yield a cheap triumph to the vaunters of cures without deformity by special methods. In the cervical region a projection rarely forms, but the neck itself is shortened.

[1] *Trans. Am. Orthop. Assoc.* vol. iv. p. 124.

[2] My friend Mr. Vincent Moxey informs me that he has seen two pregnant women with severe Pott's disease and abscess. Both patients succumbed quickly after parturition.

As to the duration of the disease, in simple cases where it is limited to the original focus, and does not spread, it lasts about three years. Far different is the case where, in addition to the destructive focus, there is extensive and spreading periosteal denudation. In this event the disease may last for one or more decades. This serious condition may be recognised by the following signs: The spine is deformed by a very long slight curve. The pain is felt more or less over the whole extent of the spine, and the patient cannot be turned in bed without complaint; he lies fixedly, and every movement, whether active or passive, causes pain. There is pyrexia without any visceral lesion to account for it, and it is indefinitely prolonged until emaciation sets in and death ensues.

The Social Condition.—Much must depend on the amount of care and attention that the patient can command. It is certain that the children of the poor, bandied about as they often are from one person's care to another, suffer more acutely, recover more slowly, and stand the strain upon the vital powers less readily than the children of the well-to-do, who can command all those hygienic measures of good food and fresh air, which are so essential to recovery whilst under surgical treatment.

An opinion will necessarily be sought as to the *duration* of the case. Each case must be judged on its merits. It is only possible to give the average duration of a number of collected cases. All statistics bearing on this point should be received with reservation, owing to the likelihood of apparently cured cases creeping in and swelling the total. It may be said that, with thorough treatment, the duration of cervical disease (excluding atlo-axial disease) is shorter than dorsal or lumbar on account of the small size of the bodies of the vertebræ, and the superincumbent weight is less in the upper parts of the spinal column. Bradford and Lovett [1] remarked that "relief from symptoms is early obtained; but, to establish a complete cure, so that there be no latent disease, requires protection and treatment for years. Roughly speaking, it is always possible to predict a course of treatment which shall last not less than three years, and probably longer." We take it these data refer to both complicated and uncomplicated cases, and we think that even in the latter class they are below the mark.

The Probability of Recovery and Danger to Life.—Reliable statistics as to the percentage of recoveries are difficult to obtain,

[1] *Op. cit.* p. 50.

since the cases must be watched through so long a period. Billroth and Menzel report 23 deaths in 61 cases; Jaffé noted 22 deaths in 82 cases; and Mohr, 7 deaths in 72 cases. Goldthwait,[1] recording the results of a series of 62 cases extending over eight years ending in 1902, and all over 12 years of age, found that 20 developed abscess and 8 died, 11 had paraplegia and 2 died, and of the rest 1 died, giving a total of 11 deaths in 62 cases in eight years. Ridlon and Jones[2] are too optimistic when they state that only 8 per cent of cases properly treated in a conservative manner die. They are nearer the mark when they say that 30 per cent of neglected cases prove fatal. In autopsies of 702 cases, Billroth and Menzel found tuberculosis of other parts in 56 per cent, amyloid degeneration was present in 15 per cent, and fatty degeneration of the kidney in 22 per cent. Bradford and Lovett quote Neidert's[3] investigations on the ultimate cause of death in patients with angular deformity, the result of caries which had been cured. Many with severe deformity die of heart lesions, those with medium-sized curves die of phthisis, whilst those with slight deformities have a good prospect of life before them. Neidert investigated 31 cases, the average age at the time of death being 49½ years: 24 of them had hypertrophy, some with and some without dilatation of the right side of the heart, 4 had cardiac muscular degeneration, 2 had stenosis of the mitral valve, 1 acute miliary tuberculosis, 8 died of phthisis, 4 of pneumonia, and 1 of carbuncle. The occurrence of narrowing and kinking the aorta in Pott's disease has already been noted (Figs. 47 and 48).

The importance of observing the *rate of growth* in cases of spondylitis from the points of view of prognosis and treatment has been ably dealt with by Taylor.[4] In an adolescent the normal annual increase in height is two inches or more. In a case of vertebral tuberculosis, an average annual growth of 1 to 1½ inches extending over a number of years is fairly satisfactory for patients under treatment during or soon after the active stage; while an annual average increase of 1½ to 2 inches indicates that the disease is arrested, is retrogressive, and the patient is doing well. Puberty itself is often delayed to the sixteenth or seventeenth year, and so is the pre-pubertial acceleration of increase in height. The growing period itself is prolonged, and an appreciable gain is possible after

[1] *Boston Med. and Surg. Journ.*, Sept. 24, 1903.
[2] *Phil. Med. Journ.* vol. i. No. 18, p. 777 *et seq.*
[3] *Inaugural Dissert.*, Munich, 1886.
[4] *N. Y. Med. Journ.*, Oct. 8, 1898.

the twentieth year. The retardation of growth is felt probably in all parts of the body, and apparatus should not be removed in the growing period unless the patient has shown a fair rate of growth for at least a year previously; if a decided retardation of growth occurs after the apparatus has been removed, it is an indication for its re-appliance.

Recrudescence of the disease in middle life is known to occur in a moderate proportion of cases, but it produces a condition of affairs less grave than the original attack, if properly treated. Increase of the deformity is due in some instances either to settling of the spine, or to progressive bony rarefaction, usually seen after the age of 50 years. It is accompanied by peripheral and visceral pains from compression, motor symptoms, and often ends in paraplegia. More often, increase of the deformity signalises a fresh tuberculous outbreak, which, according to Chipault,[1] does not affect the ankylosis already existing, but is in fact limited by it. Tuberculous abscesses of a very chronic type are common.

Causes of Death.—Tuberculosis is the chief, then come marasmus, exhaustion, lardaceous disease, spinal meningitis, surgical kidney, and the fatal results of bursting of an abscess into the trachea, pleura, lung, œsophagus, peritoneal cavity, viscera; and in one rare case perforation into a large artery occurred.

The Prognosis of Abscess.—This question may be considered from the following points of view: the region of the spine diseased, the sex and age, the extent and position of the bone involved, the presence of other complications, and the influence of treatment.

The Region of the Spine Involved.—In the cervical region abscess is less frequently a complication than lower down; and its presence is soon manifest, and therefore ensures prompt treatment. In the dorsal and dorso-lumbar regions, the greater movement of the parts, the perpetual action of large muscles, and the friction set up by the movements of respiration, must not only increase the liability to pus-formation, but tend to make it spread in many directions, when it is once present. Moreover, as we approach the lumbar and sacral regions, the probability of several foci of disease being present increases; and this fact, together with the peculiar lamination of the fasciæ and the fusiform shape of the psoas, affords a wide scope for extension. In the dorsal region of the spine, the ribs and transverse processes are sometimes involved, and form large sequestra; whilst the great depth of the bodies from the surface renders removal of diseased bone from them difficult. In the

[1] *Manuel d'orthopédie vertébrale*, p. 124.

lumbar region the same remarks apply with increased force, and in both dorsal and lumbar abscess the immediate neighbourhood of large serous cavities must be borne in mind.

Sex and Age.—Children bear the strain of abscess better than adults. Whilst spinal abscess in a child rarely fails by the urgency of the symptoms to lead to careful examination and early recognition, in the adult it often runs a more chronic course; and it is not unusual for the patient to go about with "lumbago," the cause of which is found, on examination, to be caries with the co-existence of a large abscess, hitherto unnoticed. We are inclined to think, from our experience of such patients, that their cases run a chronic and often downward course, in spite of the most approved treatment.

The Presence of other Complications.—The condition of cases presenting signs of advancing tubercle elsewhere, especially in the lungs, unfortunately calls for little comment. So, too, if hectic fever be once established, the peril is extreme. Next to abscess the most frequent complication is "compression-paraplegia." *A priori* it would appear that the occurrence of abscess during paralysis can have but one effect on the case. This serious view of the matter is not always justified. It often happens that an intra-spinal abscess, the cause of compression, finds its way outside the spinal canal and spreads itself in the soft tissues, with corresponding relief to the paraplegia.

The opposite result occurs when an extra-dural abscess forces its way through the sheath of spinal membranes. In such cases the prospect is hopeless.

In dorsal caries, symptoms of œsophageal obstruction are of grave import. They indicate that the bodies of the vertebræ are extensively involved on the anterior aspect, and that the caseating process has extended to the posterior mediastinum, with implication of the glands. The mediastinum is not a situation in which surgical interference is readily tolerated.[1]

The Method of Treatment.—This must necessarily influence the prognosis very materially, as in all abscesses. Seldom is such discrimination of methods and zealous care in carrying them out so vitally essential. We allude more particularly to the question of asepsis from first to last.

[1] Cf., however, Mr. W. Arbuthnot Lane's cases recorded in the *Annals of Surgery*, vol. xvi. pp. 314-320. J. E. Goldthwait, in writing on "Abscesses in the posterior mediastinum in connection with Pott's disease," reports one case of successful operation. Of 5 cases, 3 died suddenly, 1 recovered spontaneously, and 1 after operation. The chief symptom in these cases is dyspnœa, paroxysmal in character, without obvious affection of the larynx, trachea, or lungs.

CHAPTER IV

VERTEBRAL TUBERCULOSIS—*Continued*

Treatment

General and Local Treatment of Uncomplicated Caries—Vaccine Treatment—Treatment of Abscess and Discussion of the various Methods—Treatment of Compression Paraplegia, Conservative and Operative—Occipito-Atloid and Atlo-Axoid Disease (Spondyl-Arthritis Tuberculosa)—Vertebral Tuberculosis in Infancy and Childhood—Spondylolisthesis.

Tuberculous spondylitis is always a serious condition; but, in many cases, it is very amenable to treatment. An idea is current that rest on the back for three months, and then a plaster or poro-plaster jacket, are all-sufficient. If the case is seen in its early stages, deformity may be prevented or reduced to a minimum. In the absence of complications, cure will most readily be obtained in the cervical, upper dorsal, and lumbar regions; less readily and with more difficulty in the lower and mid-dorsal regions. The method of cure is by ankylosis (see p. 64), and when the disease is treated early and thoroughly the number of ankylosed vertebræ is small, the patient having a very useful back. The best treatment consists of early diagnosis, of prolonged rest in the horizontal position, and avoiding the temptation of putting the patient into spinal supports too soon; for prudence, even extreme, in this particular, is never excessive. The treatment must extend over years, and the ultimate results are often such as to give solid satisfaction both to the patient and surgeon. Treatment may be described as general and local.

General Treatment.—There is, unhappily, no specific remedy for this disease, and we place no reliance on preparations administered internally. Fresh air and sunshine[1] are most valuable.

[1] It is futile to attempt to treat tuberculous caries in towns. At all costs patients should be sent to the seaside or country, and be in the open air. Absorption of abscesses is not rare amongst patients so treated, but it is exceptional among those who

It is the deprivation of them, together with insanitary surroundings and bad food, that renders the treatment of poor patients so tedious. When urgent symptoms have subsided, the patient should be sent away to one of the East Coast seaside resorts, or failing them, to an elevated dry place in the country. The food should be regular and plentiful, avoiding saccharine and starchy constituents in excess. Much meat is not well borne by children, and eggs and milk are to be preferred. The stomach and bowels must be regulated and constipation prevented. The best laxative in children is petroleum-emulsion, at bedtime. Cod-liver oil, or one of the malt extracts, is useful, and we may from time to time give iron in the form of syr. ferri phosphatis co., or syr. ferri iodidi, ℨss thrice daily. In the early stages of recumbency, patients often suffer from flatulence due to want of exercise, the new position, or to excessive feeding. However, a little care gets rid of the difficulties. The value of tuberculin injections in these cases is still *sub judice*. Our experience in this direction is very limited, and we are not able to speak decidedly. In the few instances where we have employed it the effect has not always been beneficial, and some patients have lost weight and become thinner. It may be that we did not regulate the dosage properly, but probably the presence of sessile spinal abscesses in some way limited or prevented the action of the vaccine.

Treatment directed to the Spine.[1]—The principles of treatment are three:—

(*a*) To fix the vertebral column so as to take the tension off the area of disease and place the spine in the best possible circumstances for healing.

(*b*) To remove the weight of the upper part of the body from the diseased vertebræ.

(*c*) To prevent, as far as possible, unnecessary deformity by supporting the trunk, especially behind, over the area of disease,

do not leave their rooms. If an abscess is not absorbed, but is treated by aspiration and injections, a cure follows without a fistula, if the open-air treatment is conscientiously followed, and even apparently desperate sinus-cases sometimes recover (Ménard, *op. cit.* p. 304).

[1] Chipault, in *Suite de monographies cliniques*, No. 2, June 1897, "Le Traitement du Mal de Pott," gives an excellent summary of the work done by surgeons on the subject up to this date, and his more recent work, *Manuel d'orthopédie vertébrale*, well repays perusal, although his own views occupy too large a space in the book, especially as they have not met with general acceptance.

and in front; and if deformity has occurred, to lessen it, and certainly to prevent its increase.

To carry out these principles we have two methods at our disposal, viz. recumbency and the use of retention-appliances. They may be employed separately, or in combination in individual cases, but they can never be used indiscriminately. The precise value of each varies according to the age, stage of the disease, and the regions involved. Horizontal decubitus removes the weight of the body and prevents flexion. Corsets merely prevent flexion, but do not take off the body-weight.

Recumbency.—Indications for:—

1. In all cases of commencing Pott's disease—the pre-deformity stage, a stage at which too often apparatus is relied upon and proves fallacious.

2. In more advanced cases to prevent abscess and paralysis, and increase of deformity from destruction.

3. In all acute cases in which there are considerable pain, distress, and impairment of the general health, with loss of flesh and colour.

4. When, on employing the "palm-pressure" test to the back, it is found to be yielding.

5. When paralysis and abscess are present.

6. If the patient bears apparatus badly.

7. In those patients who become easily tired on their feet; and in those who, apparently well supported mechanically, frequently desire to lie down.

8. In children, recumbency may be resorted to for longer periods without detriment to the general health than in adults.

The immediate effects of recumbency are good; the pain disappears, the nervous irritability is lost, the face loses its anxious aspect, and the patient often puts on fat, although the muscles of the limbs diminish in size. Recumbency means rest to the focus of disease, diminution of flexion, avoidance of compression-ulceration, and absence of muscular contraction; and it is the surest means of avoiding extensive periosteal denudation, abscess, and paraplegia. It is also the most efficient mechanically, and is the best preventive of deformity in early cases.

The *absolute necessity* and *advantages* in most cases are evident. The relief of pain; the limitation of the deformity, and in many cases its recession; the gradual clearing up of paresis, and the cessation of increase in the size of an abscess, are all good points. The improvement in the general health is striking and immediate, but the recumbency should be carried out in the open air.

The *disadvantages* are, that in adults there may be, but by no means always is, after a comparatively short improvement, a marked decline in the general health; anæmia and constipation ensue, and wasting again appears. In children it is otherwise. It must be clearly borne in mind that when recumbency is ordered, it must be absolute so long as it lasts. If the patient is suffering from feeble digestion, loss of appetite, constipation, excessive fatness, or circulatory changes, causing headache or vertigo, Ménard's suggestion is valuable—after a prolonged period of rest an immovable plaster corset is put on, and the patient allowed to roll on the couch, crawl on the hands or feet, and even play, so long as he does not stand up.

The *duration of recumbency* can scarcely be specified in set terms of time. Each individual case must be judged on its merits. At the Royal National Orthopædic Hospital I am accustomed to keep children recumbent until all pain has disappeared; until the palm-pressure test shows the back to be consolidated; and until, with a little support from the nurse, the child can be sat up carefully for a few minutes, such alteration of position neither being accompanied nor followed by pain. In cases which are doing well the patient becomes restless, moving his arms and legs freely, fidgeting constantly, or even attempting to turn over. It is an irreparable fault to promise a cure in some months. It never takes place, and the surgeon loses all his authority in imposing rational treatment. Do not temporise, but follow out a rational line of treatment until it has given a result. Complete consolidation of the spine does not take place in two years, and rarely in three years. However, when the above signs of improvement are evident, generally in eighteen months, the question of a spinal support may be entertained.

Points to be Noted in Placing a Patient Recumbent

1. Efficient Nursing. This point applies more particularly to patients treated at home. A nurse with experience of this disease should be secured, and if it is not possible for her to stay with the patient during the whole of the illness on account of expense, she should remain a sufficient time for the attendants to learn the details of nursing. Her duties consist more particularly of ensuring

thorough cleanliness without any undue disturbance of the back, and the prevention of bed-sores. The skin over the prominent parts is to be cleansed, hardened with methylated spirit or eau-de-Cologne, and powdered daily. She should also take the temperature night and morning, and record the pulse, respiration, and actions of the bowels.

2. Clothing. Flannel is to be worn, and the garments are best made in the form of night-gowns, which can be put on from the front, having the opening made the whole length of the back. Tapes are used for tying, and buttons are avoided.

3. The couch the patient lies on must be firm, not concave and not too hard; and pillows, except a small ring-shaped pad for the head, are not advisable.

4. Air- and water-beds are not to be used because of their instability. Bed-sores are evidence of bad nursing.

5. For children, and for adults in the early stages of recumbency, some retentive arrangement is necessary to prevent movement (see pp. 141, 142).

6. Extension of the spine is valuable in all cases, and can be obtained by applying weights to the head and feet, or to the feet only and raising the lower end of the bed. It is important that the lumbar spine be not allowed to flatten gradually to the bed. From the first, it is better to procure lordosis here, so as to aim at lessening the posterior deformity; and in all cases, treated in the pre-deformity stage, the lumbar spine should be arched forward. Thus deformity is anticipated and prevented. If it is present it can undoubtedly be lessened, and in some cases effaced. Inter-segmental pressure is also relieved, and the acute symptoms subside early.

7. Whatever form of couch is used, it is placed on wheels, in order that it may be easily moved into the open air.

8. The choice of positions—prone or supine? In the majority of cases the supine is preferable, although it may be replaced by the prone for a short time to avoid bed-sores. Obviously, in cervical disease, where extension is necessary, the supine position alone is available. Rédard[1] strongly advocates the prone position in those dorsal cases where the deformity is commencing, where there is a good deal of irritation and contraction of the muscles, and paralysis is rapidly setting in. He claims that in four of eight cases he obtained a considerable diminution of the prominence, and in three

[1] *Traité de chirurgie orthopéd.* pp. 244, 245.

the deformity was not increased. The prone position has certainly the advantage of placing the congested spine uppermost.

Methods of Ensuring Complete Rest

1. That which is usually adopted in this country requires the following apparatus. A firm couch on wheels, covered with a good

FIG. 62.—The author's Spinal Pillow (see text). *a, b* is the groove for the spinous processes; *c* and *c'* is "stay" material, which is laced over the chest and abdomen; *d* and *d'* are two wings of soft material and are fixed to the couch. The pillow is convex from above downward, and from side to side.

horsehair mattress, and having an aperture in the centre for sanitary purposes, can be easily and cheaply made. I have designed and largely used a pillow (Figs. 62 and 63), which is placed beneath the area of disease and for some distance above and below it. It is convex from above downwards, and is centrally grooved in the same direction so as to receive the spinous processes, whilst pressure is made upon the transverse processes. It is stiffened in the required situations with felt. To each side of the pillow two pieces of stay material are attached. The upper pieces from each side are of such a size and so provided with lacing that they can be laced across the

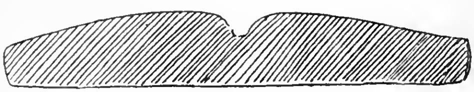


FIG. 63.—Transverse section of the author's Spinal Pillow.

chest, and help to keep the child recumbent. The lower pieces on each side are fixed by safety pins, or by stitching them to the sheet and mattress, so as to prevent movement or any attempt at turning

FIG. 64.—The author's method of treatment in the Open Air by Recumbency, Spinal Extension, and Counter-extension by Weights, and by Hyper-extension of the diseased area by means of the Spinal Pillow.

over. If the pillow itself is covered with macintosh it is easily cleaned. After a month or so it requires making up again, as the

FIG. 65.—The same as in the preceding figure, except that the "Stay" material is laced into place, and the straps for the attachment of the spinal pillow to the couch are displayed.

effect of constant pressure is to flatten it. Its use prevents deformity in early cases, and helps its recession and sometimes its disappearance.

In children, it is in my opinion advisable to apply weight-extension to the lower extremities by means of stirrups, and they should always be carried above the knees, so as to limit the pull upon the ligaments of those joints. When desirable, especially in cervical and upper dorsal caries, head-extension can be added (see Figs. 64 and 65). As a rule this arrangement answers admirably, and the child lies entirely still, more particularly during the active stage of the disease, but later it often becomes restless by day or turns in its sleep, and then Fisher's bed-frame is useful (Fig. 66). In the absence of head-extension, the body-weight may be utilised to counteract the traction on the lower extremities by raising the lower end of the couch.

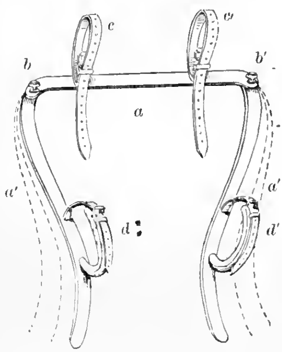


FIG. 66.—Fisher's Bed-Frame, used in the treatment of Tuberculous Spondylitis by Recumbency. *a* is a transverse band of metal, hinged at *b* and *b'* to two curved pieces, *a'*, which lie alongside the trunk; *c* and *c'* are straps for attaching the frame to the bed-rail; *dd'*, leather loops, through which the patient's arms are passed as far as the axillæ. The effect of the frame is to keep the patient at rest in the horizontal position.

A modification, designed by Dr. H. J. Gauvain, of the spinal board, in use at the Maritime Hospital, Berck Sur-Mer, fulfils admirably the requirements of complete recumbency. The apparatus is described and figured in Appendix II. of this volume.

2. When the curvature is cervico-dorsal, a spinal suspension board (Fig. 67) is very serviceable. At first it is used with the upper part raised, from ten to fifteen minutes at a time, and this period is gradually increased until the child passes hours and even sleeps thus. At other times he is recumbent on the board and pillow. The effect of treating these cases by suspension is very marked, relief of intervertebral pressure is obtained, and deformity recedes. Yet, some children do not bear it well. Instead of muscular rigidity diminishing, it increases, and there is sometimes elevation of temperature. In such cases its use should be abandoned.

3. Bradford and Lovett[1] strongly recommend a gas-pipe bed-frame (Fig. 68), and this seems to me a simple and cheap way of treating cases in the recumbent position. We transcribe the description directly from their excellent treatise. "The rectangular

[1] *Orthopedic Surgery*, 2nd ed. p. 42. Cf. also the description of Schapps' frame, *N.Y. Med. Journal*, Aug. 1, 1896.

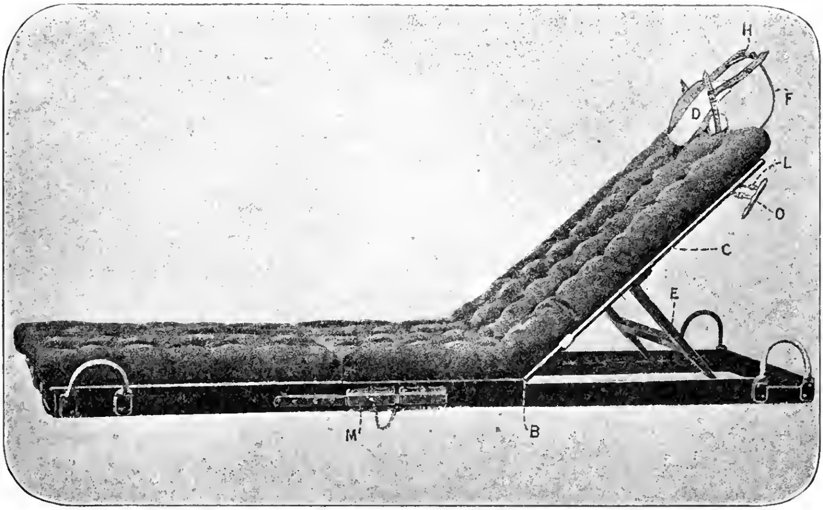


FIG. 67.—Spinal Suspension Apparatus. B, hinge in frame; C, upper part of frame; D, head-strap, suspended from a metal cross-piece, H, carried on a metal stem, F, which is raised or lowered by means of a rack and screw, worked by a handle at O, and fixed by a set-screw, L; E, rack-adjustment for upper part of couch; M, sliding-board for sanitary purposes (Ernst).

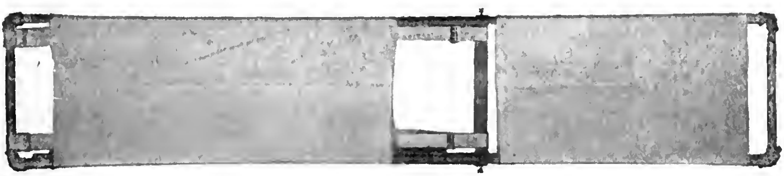


FIG. 68.—The Gas-Pipe Frame, with canvas stretched over it, and sanitary aperture (Bradford and Lovett).

FIG. 69.—The patient placed on the Gas-Pipe Frame (Bradford and Lovett).

bed-frame consists of a stretcher of heavy cloth attached to a rectangular gas-pipe frame. The frame is made of straight pieces of galvanised iron gas-pipe (one-half to one inch in diameter), screwed into gas-fitters' joints at the four corners. This frame should be four or five inches longer than the patient, and its width should be a little less than the width of the shoulders.

"The covering-cloth is best made of heavy, unbleached cotton-sheeting stretched firmly over the stretcher. The covering should consist of two pieces of such length that the entire space is covered

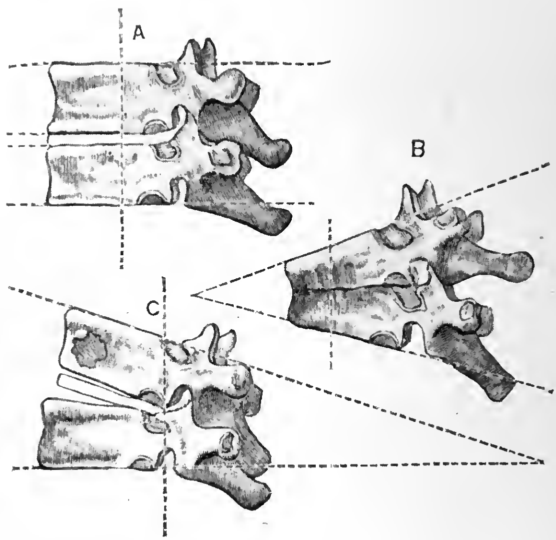


FIG. 70.—Diagram to show the effect of Hyper-extension of the area of disease. A, the normal position of the adjacent vertebra; B, falling forward of the vertebral bodies in caries of the spine; C, the aim of treatment by means of hyper-extension (Tunstall Taylor); ...., the planes of the vertebral bodies; ⁝, the lines of the centre of gravity and of the superincumbent weights.

by cloth, except for a space of six inches or less between the two sections at a point corresponding to the buttocks. The child, lying upon this frame, can be secured by means of straps across the shoulders and pelvis and knees, and can be carried about without fear.

"But simple recumbency is not sufficient to favour cicatricial ostitis. The removal of intervertebral pressure is desired[1]

[1] Cf. R. Tunstall Taylor, "Hyper-extension as an Essential in the Correction of the Deformity of Pott's Disease," *Johns Hopkins Hosp. Bull.* vol. xii. No. 119, Feb. 1901. He has designed an apparatus for securing hyper-extension of the spine both in recumbency and after the plaster of Paris jacket is applied in the suspended position. He terms his apparatus the "kyphotone" (Figs. 75 and 76).

(Fig. 70). This is to be accomplished by arching the spinal column forward at the point of the kyphotic curve, by placing under the child a firm pad pressing upon each side of the spinous processes, and sufficiently high to press the (affected) part upward,

FIG. 71.—Silver's Modification of the Gas-Pipe Frame, designed to secure Hyper-extension of the Spine (Bradford and Lovett).

while the rest of the spinal column drops back by its own weight; or by bending the frame (Fig. 71). Head and leg traction can be easily provided, and the frame can be readily mounted on wheels."

Whitman[1] has modified this frame in several particulars, the most important being as follows: "As soon as the patient has

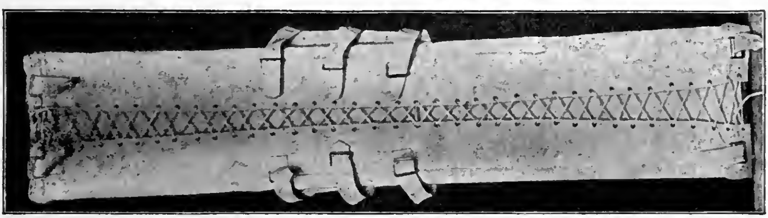


FIG. 72.—The Stretcher Frame, showing the Canvas Cover and Apron (Whitman).

become accustomed to the restraint, one begins to over-extend the spine by bending the bars from time to time upward beneath the kyphosis (Fig. 73), with the aim of actually separating the diseased vertebral bodies and obliterating all the physiological curves of the spine, so that the body shall be finally bent backward to form the segment of a circle. The greatest convexity is at the seat of the disease, and as the head and lower extremities are on a much

[1] *Orthop. Surg.* 2nd ed. pp. 68, 69.

lower level, an element of gravity-traction is present in some

FIG. 73.—The Frame bent to secure Over-extension of the Spine (R. Whitman).

instances, while the support of the spine as a whole is much more comprehensive than when the body lies upon a plane surface. The

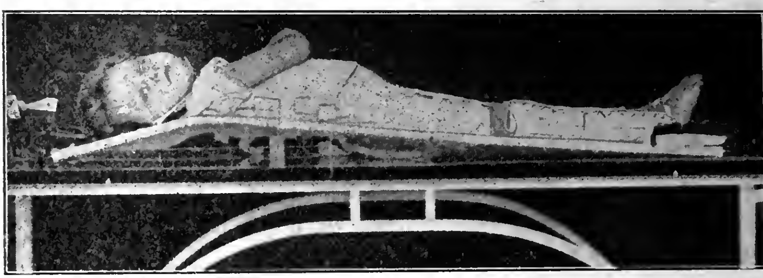


FIG. 74.—The Modified Stretcher Frame showing Over-extension of the Spine, with Traction for the Head and Limbs, as applied for Pott's paraplegia, caused by disease in the upper dorsal region (R. Whitman).

method of attaching the patient to the frame is, in ordinary cases, by a canvas apron which is buckled to the sides of the frame (Fig. 72).

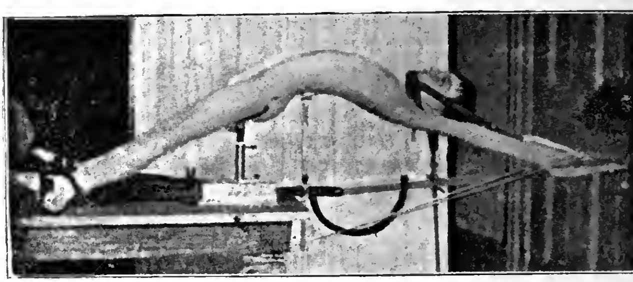


FIG. 75.—Tunstall Taylor's large Recumbent Kyphotone.

Additional fixings may be applied, if called for, to the chest, arms, and pelvis."

Whilst advocating and preferring the more gradual methods of securing hyper-extension of the spine, yet a brief notice of Tunstall

Taylor's more rapid procedure may be given. Its application presupposes great skill and experience in estimating the condition of the spine, the relationships of the affected vertebræ to the cord and to each other, and the presence or otherwise of abscess — conditions which may be partially determined by a series of carefully-taken skiagrams. The essential part of Tunstall Taylor's

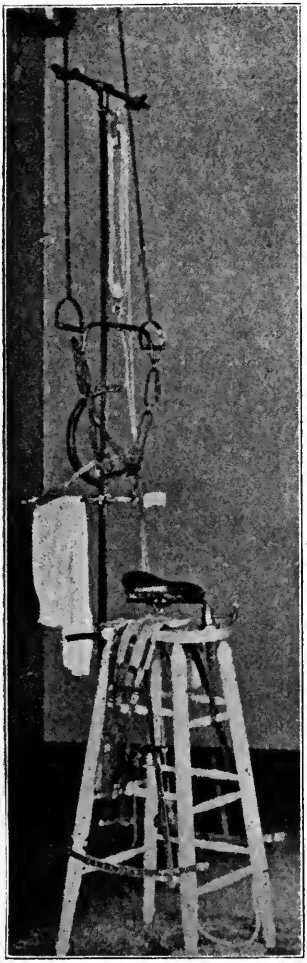


FIG. 76.—Tunstall Taylor's Vertical Kyphotone. Its action is explained by the next figure.

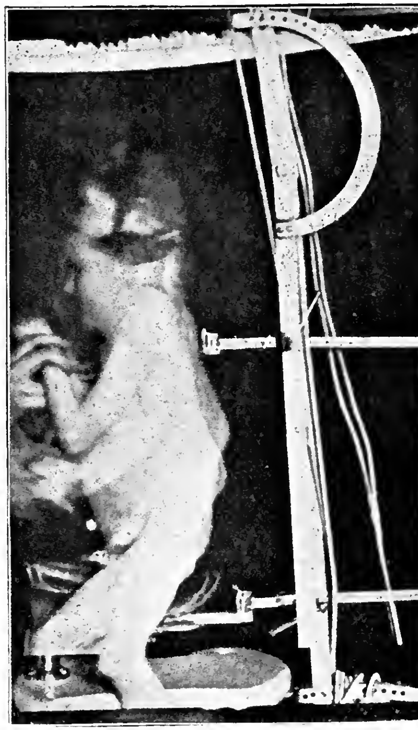


FIG. 77.—A Double Photographic Exposure. The lower figure represents the child in the sitting posture. The upper figure shows the child suspended by the head with no reduction of the kyphosis, *i.e.* the normal curves are merely straightened out (Tunstall Taylor).

method is the use of an adjustable mechanical arrangement, applied either in the horizontal (Fig. 75) or in the vertical position (Fig. 76), and designated a "kyphotone." Its mode of employment can be easily appreciated by reference to the figures 75, 78, and

79. The apparatus is one which, in unskilful hands, may be productive of considerable harm.

Whitman,[1] however, adds: "I have never seen other than favourable results from this method of treatment. Pain and discomfort are as a rule relieved almost immediately. The growth of the trunk,

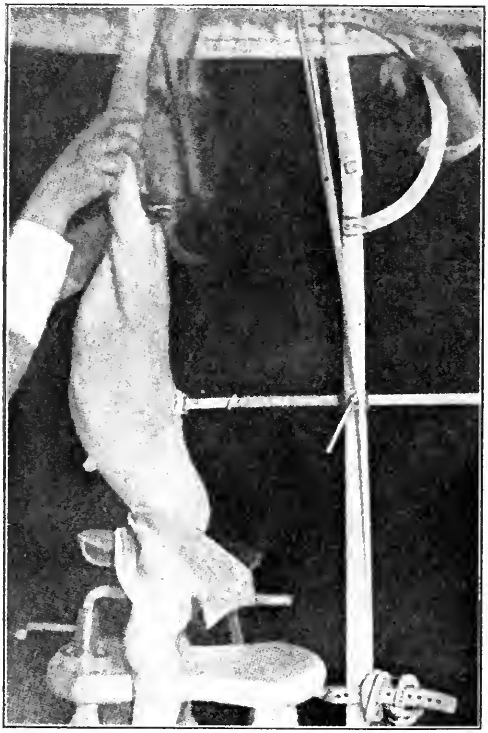


Fig. 78.—The child is hyper-extended, the Kyphotone is applied, and there is partial obliteration of the Kyphosis (Tunstall Taylor).

Fig. 79.—A patient showing the result of reduction by the Kyphotone (Tunstall Taylor).

which is so often checked by the disease and deformity, appears to progress with normal rapidity."

A Phelps' box (Figs. 80 and 81), with a cushion beneath the prominence, is very useful for poorer patients. On the Continent Lorenz's "Reklinations Bett" (Figs. 82, 83, and 84) is much in use. By the French it is called the "lit de plâtre." It is a plaster of Paris casing, so moulded as to produce separation of diseased

[1] *Op. cit.* p. 73.

surfaces by setting up lordosis; in cervical cases extension is added. The advantages presented are cheapness and simplicity, security of fixation, and the possibility of modelling it to any spinal condition. Before applying the plaster, the child is placed prone, either with pillows under the ankles, thighs, chest, and head, to produce lordosis; or a Rédard's prone table (Figs. 85 and 86) is employed, which is hinged a little nearer one end than the other. Finck simply places the child prone, with the elbows bent, resting the face upon the hands, thus ensuring lordosis.

As we have previously stated, even in the mildest cases the

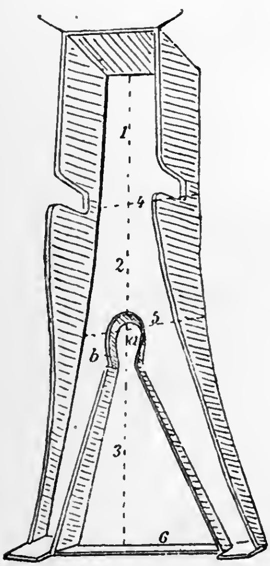


Fig. 80.—Phelps' Box, used in the Treatment of Tuberculous Spondylitis (Rédard).

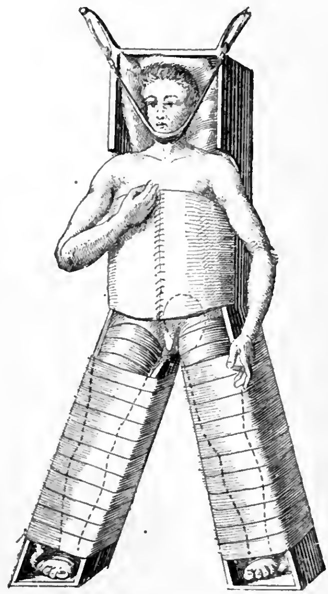


Fig. 81.—The patient in the Phelps' Box (Rédard).

duration of recumbency is twelve months, and the transition should be gradually made when the signs described on p. 171 are evident. Whatever apparatus is used, the patient begins by sitting up in it first at an angle of 45°, then of 60°, and then of 75° for 10 to 15 minutes once a day. This period is gradually extended until the child is able to sit up for two hours. Then walking is commenced. Finally, the child resumes to a great extent his ordinary life, but in every case of cured tuberculous caries the patient is well advised to make a practice of lying down for at least one, or better, two hours daily.

Ambulatory Treatment.—Various appliances and apparatus are employed, but we propose to limit ourselves to descriptions of three supports, viz. the plaster of Paris corset, the steel spinal support, and the Taylor brace.

Essential Points in the use of Spinal Supports.—All supports must fulfil these conditions :—

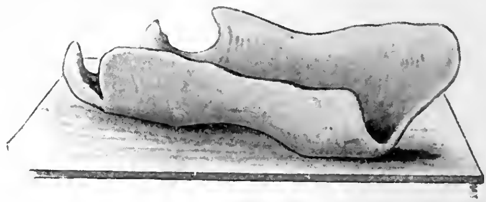


Fig. 82.

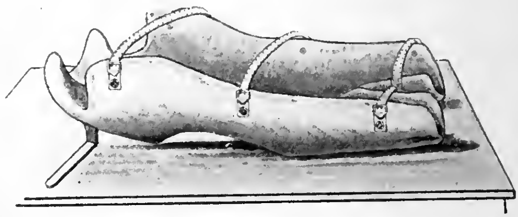


Fig. 83.

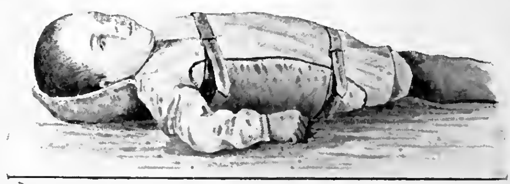


Fig. 84.

Three figures, representing Lorenz's Reklinations Bett (*lit de plâtre*, plaster bed).

1. They must have a good firm base. This is obtained by an accurate fitting around the pelvis.

2. They must exercise a moderate amount of pressure on the transverse processes at the site of the disease, so as to resist the backward thrust.

3. In all cases of disease in the dorsal or lumbar region support must be given, to prevent the chest falling forwards. This may be

done by means of steel crutches in front of the shoulders, or when the plaster of Paris jacket is used, by specially thickening the plaster over the chest.

Rules which we regard as absolute in the application of spinal supports are that, in all cases of disease above the tenth dorsal vertebra, anterior shoulder supports, to effect backward traction, must be used; and in all cases of disease at or above the eighth

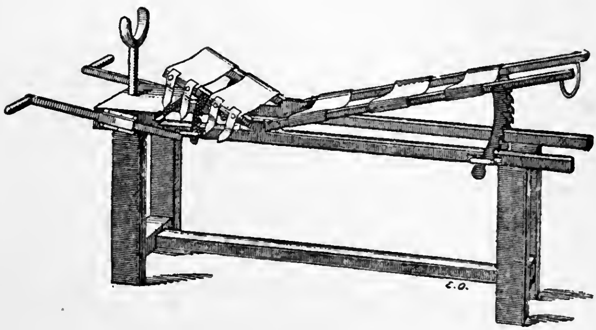


FIG. 85.

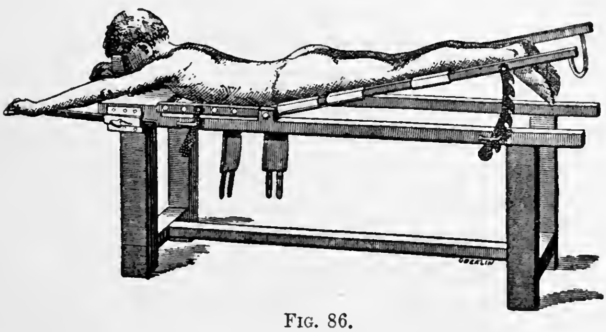


FIG. 86.

Two figures, representing Rédard's Spinal Hyper-extension Couch.

dorsal vertebra a head support is essential[1] on account of the immense leverage forwards exerted by the weight of the head, neck, and shoulder-girdle. Poroplastic jackets are not satisfactory. They are somewhat expensive, they do not give support either over the site of the disease behind, or to the chest in front, and they quickly become soft and useless. Other materials are used for spinal jackets,

[1] The instances of disregard of this obvious mechanical fact which we have seen are ludicrous. In one case, a patient with disease of the sixth dorsal vertebra, came to us with a plaster of Paris jacket which reached to the level of the disease only. In another case part of the spinal projection was above the jacket.

such as leather,[1] aluminium, celluloid, papier-maché, silicate of potash; but they are either expensive, difficult to apply, or present other disadvantages.

The Plaster of Paris Jacket.—In early Pott's disease, when the patient is suspended, not only do the physiological curves become straightened, but to a small extent the projection is diminished. The projection can be further lessened if the jacket is applied with the spine somewhat hyper-extended on the plan advocated by R. Tunstall Taylor, either in the suspended (Fig. 78) or in the supine position (Fig. 75). Intervertebral pressure is certainly lessened, and the good effects of the jacket are dependent partly upon hyper-extension and partly upon the thorough fixation of the trunk in an improved position, in fact it is a circular splint. The disadvantages of jackets are that they are uncleanly, the condition of the back cannot be watched, nor can examination be made for abscesses, and they are also liable to irritate the skin. Other difficulties present themselves if a discharging sinus is present. Experience, however, shows that most of the objections can be overcome by patience and ingenuity.

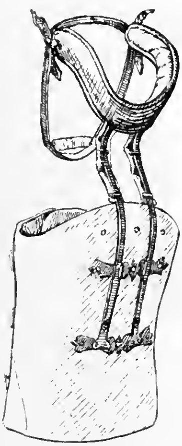


FIG. 87.—Poroplastic Jacket with Occipital Head-piece for Cervical and Dorsal Caries (Ernst).

The Application of the Jacket.—It is essential that the materials used should be of the best. The most frequent causes of failure are using the wrong kind of plaster and improperly prepared bandage material. The plaster is fresh *dry* dental plaster, and the bandages are made either of crinoline freed from glue-sizing by being washed in water, or of loose meshed cloth free from oil. The plaster is either rubbed in by hand, or forced into the material by means of air-pressure, just before being applied. If bandages are stocked, they should be kept in air-tight tins, and even then the tins should be opened a little time before use, and the bandages placed in a hot oven for fifteen minutes, so that all moisture may be removed. In this case alum will not be required to hasten the setting.

A seamless, closely-fitting vest, reaching from the neck to the knees, is worn. Beneath the shirt and next to the skin, strips of linen or of China silk, three inches in width and three feet in length,

[1] A. J. Steele, *Trans.* (Pamphlet), gives an excellent description how to make a leather splint, under the quaint title of "Pointers on the Leather Splint."

are placed. These strips are for the purposes of cleanliness. The patient is then seated on a stool, and the suspensory apparatus is applied to the chin and occiput, the arms being raised above the head and grasping the straps, thus securing the position of full expansion of the chest. The pulley cord is now tightened just sufficiently to extend the spine. It is better not to employ a greater extension-force than this, because the patient, if entirely raised off the stool, readily becomes tired and is liable to faint.

Care is now taken to protect all the bony points and surface with strips of felt, particularly the sternum, anterior superior spines, crests of the ilia, and the sacrum; and pressure on the spinous processes is prevented by long strips of felt laid longitudinally over the lines of the transverse processes. The breasts are protected with cotton wool; and in adults a dinner-pad is used, which is not necessary, however, in children as a rule, although some complain of a feeling of tightness. If this be the case, a dinner-pad is used and the jacket re-applied. Eight bandages for an adult and six for a child are generally required, and they should be six yards long and three inches in breadth. They are placed, on end, in a vessel containing warm water, sufficiently deep to cover them entirely; and they are allowed to soak until no more air-bubbles rise. Not more than one bandage is soaked at a time. It is then taken from the water, squeezed gently, and applied. Two assistants at least are needed, one in front and one behind.

There are three fixation-points—the pelvis, the seat of disease behind, and the front of the chest above. Therefore we begin to put the bandage on low down, *i.e.* well below the crests of the ilia, and make a firm pelvic band (Fig. 88); then we carry the bandage lightly round and round the trunk to beneath the axillæ. Now we strengthen the jacket by passing the bandage obliquely, at first from the front of the pelvis below to the upper lumbar region (Fig. 89), and then with increasing obliquity over the projection and above it, so that two fixation-points are now firmly guarded. It remains to form the third fixation-point—over the front of the chest. This is effected by carrying the bandage to the front of the chest (Fig. 90), and passing it obliquely around the trunk from the chest in front to the pelvic band behind, and then with turns of decreasing obliquity around the lumbar region and over the projection, taking care to keep it thick over the upper part of the front of the chest, the folds of bandage here lying one on another. It may now be finished off by encircling the whole trunk horizontally from above downwards

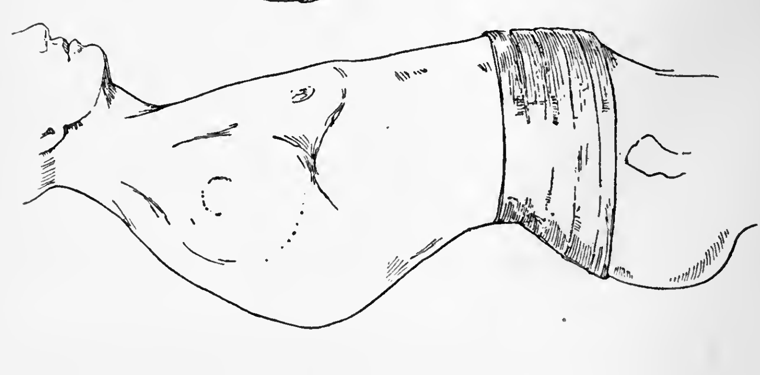


Fig. 88.

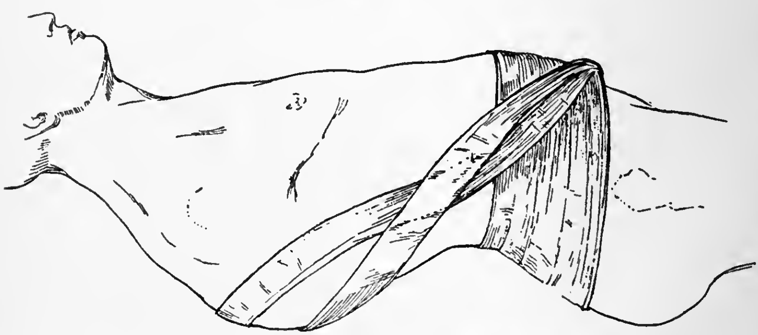


Fig. 89.

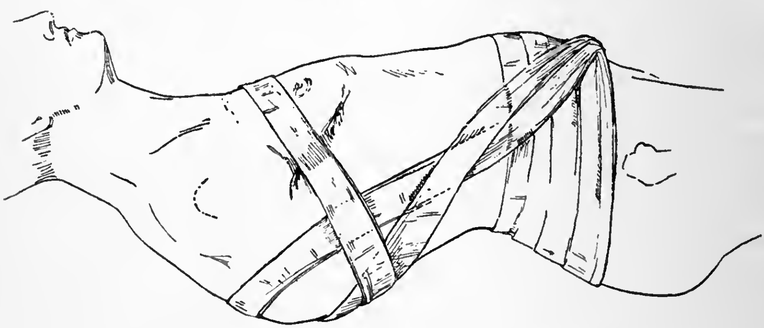


Fig. 90.

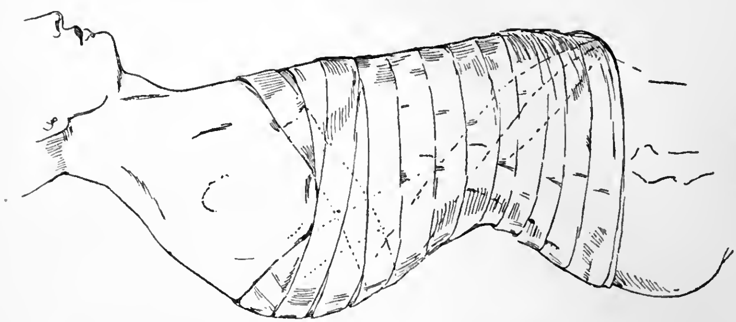


Fig. 91.

Four figures to illustrate the method of applying a Plaster of Paris Jacket, described in the text. In Fig. 88 a firm pelvic band is made low down. Fig. 89 shows the lower loop of the figure-of-8 turns, designed to form a strong support against the backward thrust of the kyphosis. In Fig. 90 the turns of the upper loop of the figure-of-8 cross the front of the chest and are thickened there, so as to counteract the falling forward of the chest. In Fig. 91 the jacket is completed by horizontal turns around the trunk.

(Fig. 91). Plaster should be rubbed in with the hand from time to time, especially around the pelvis, and over the back, and at the front of the chest.

When the jacket is nearly set, it is trimmed, and the dinner-pad is removed by traction on the linen bandages which have been fixed to its lower edge. The trimming can be done in the recumbent position, if the patient is fatigued. The jacket ought to reach in front from the upper margin of the sternum to the pubes, and behind from just below the spines of the scapulæ to the gluteal folds, whilst at the sides it should finish just short of the axillary folds. At the groins it is trimmed away in lines, curving above Poupart's ligaments.

Whilst the jacket is drying, the patient is placed in the recumbent position with a pillow beneath the most prominent part of the spine, so as to ensure that it does not sag in the setting, and to secure some degrees of hyper-extension. A considerable time should be allowed for it to become hard. The process is often not complete for some hours. In the meantime, that part of the shirt projecting below is drawn upwards and sewn to the neck portion; the latter fits tightly so as to prevent crumbs getting beneath the jersey. Whitman suggests that in many instances a special bib or collar may be used in addition.[1] The upper and lower ends of the linen strips or cleaning bandages are then joined with tape, and the skin is rubbed twice daily, by pulling vertically on them; others can be substituted, when dirty. If the disease is above the eighth dorsal vertebra, shoulder traction and head support are necessary. The former can be made by incorporating in the jacket a double steel upright, one portion on either side of the spinous processes, and in outline somewhat less convex than the prominence. The upper end of each steel support is curved outward to reach the axilla, and then terminates in a horn-like process, which, when padded, presses gently into the space between the coracoid process and the head of the humerus on either side. The two vertical uprights are connected together behind by cross-bars above and below. They are quite simple in construction, and can be made by any intelligent smith. In order to support the head, the lateral pieces may be riveted on separately, and the vertical portion continued upwards, following nearly the line of the neck, and be made to terminate in a head-piece to which a sling

[1] For many suggestions on the application of jackets, we are indebted to Whitman's excellent description in *Orthopedic Surgery*, 2nd ed. pp. 82-89.

for the chin can be added. Jury-masts are not advisable. They are unsightly, cumbersome, and too often the steel is not made sufficiently resistant to stand the strain.

Head-supports should terminate in a firmly moulded pad which lies below the superior curved lines of the occiput, and thence a chin lever is carried forwards which tilts the chin slightly upwards and backwards, and steadies it (Fig. 92). All chin levers and supports cause recession of the part after a time, but when they are discontinued, this deformity gradually disappears.

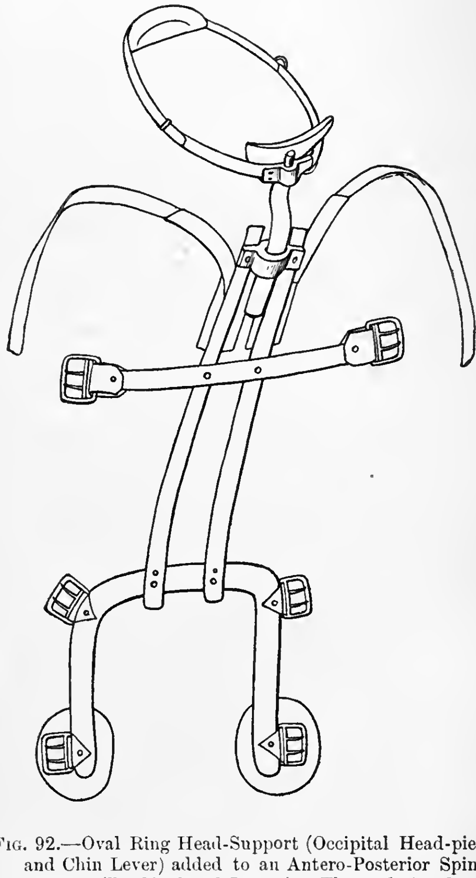


Fig. 92.—Oval Ring Head-Support (Occipital Head-piece and Chin Lever) added to an Antero-Posterior Spinal Support (Bradford and Lovett). The oval ring head-support can also be added to a plaster jacket, with a little adaptation.

Walsham practised a method of head-support which is efficient but cumbersome. The plaster of Paris jacket is carried up over the neck and head in such a way as to encircle the forehead and face, and support the chin. Patients, however, do not readily tolerate this arrangement. R. Davy of the Westminster Hospital originated the hammock method, in which the plaster jacket is applied in the extended prone position. This method has of late gone out of use to a great extent.

Plaster can be most efficiently applied in the supine posture by means of Goldthwait's apparatus (see Fig. 99 on p. 199). It gives better results than the suspension method, more especially as the spine can be maintained during the application of the jacket in positions either of full extension or moderate hyper-extension, so far as the physiological curves are concerned, and to a much less degree, at the site of disease and deformity. In fact, Goldthwait's stretcher frame has greatly increased, if not doubled the efficiency of the plaster jacket, and is nearly, if not quite an ideal treatment (Wallace Blanchard). The apparatus consists of a support carrying on its upper extremities two thin strips of perforated metal. To these strips felt is attached as in the back-brace. The patient is then placed with his back resting on the pads at the seat of disease. The buttocks and head are allowed to sink downwards to the point of toleration, so that an extending force is exerted on the spine. The plaster bandages are then applied in the usual manner about the body. When the plaster has hardened, the patient is lifted from the support, the pads of course being included in the jacket. Other supports on the same principle have been designed, notably Tunstall Taylor's.[1] A vital point in the treatment of spinal caries is so much hyper-extension, as is consistent with the integrity of the skin.

The Taylor Brace.[2]—"As the chief motion of the spine to be guarded against is the forward motion, the principle of the appliance is that of an antero-posterior support. This was first efficiently applied by Dr. C. F. Taylor of New York.[3] The construction and application should be superintended directly by the surgeon. A cardboard tracing of the spine should be made. The simplest antero-posterior apparatus (Fig. 93) consists of two uprights of annealed steel, three-eighths or one-half of an inch in width, and thick enough to be rigid. The gauge numbers of the

[1] *Johns Hopkins Hospital Bulletin*, vol. xii. No. 119, Feb. 1901. Tunstall Taylor gives numerous diagrams to illustrate the rôle of hyper-extension in separating the diseased centra, and relieving pressure on them (see p. 144).

[2] Taken *verbatim* from Bradford and Lovett's *Orthop. Surg.* 2nd ed. p. 59 *et seq.* In this connection C. F. Taylor's original pamphlet (*New York Med. Soc.*, 1863) will repay perusal. Henry Ling Taylor, *Trans. Amer. Orth. Assoc.*, 1902, gives the results with scrupulous fairness in thirty-nine patients who had worn the Taylor brace from ten to thirty-seven years. His article is a strong plea for the long-continued use of spinal supports, even in cured Pott's disease. He points out a fact, only too well known to orthopedic surgeons, that in a considerable number of cases after careful treatment, the removal of the support is followed by a gradual increase in the rounded projection, without the appearance of any sharp prominence, or any return of the spasmodic stiffness, or other indication of disease. This is due to the static conditions to which the spine is exposed; although it is free from active tuberculosis, it is physiologically weak and vulnerable.

[3] In England the principle of an antero-posterior support was first enunciated and put into practice by the late E. J. Chance at the City Orthopædic Hospital, and quite independently of C. F. Taylor.

steel as to thickness should be from eight to twelve. These uprights reach from just above the posterior superior iliac spines to about the level of the second dorsal vertebra. They are

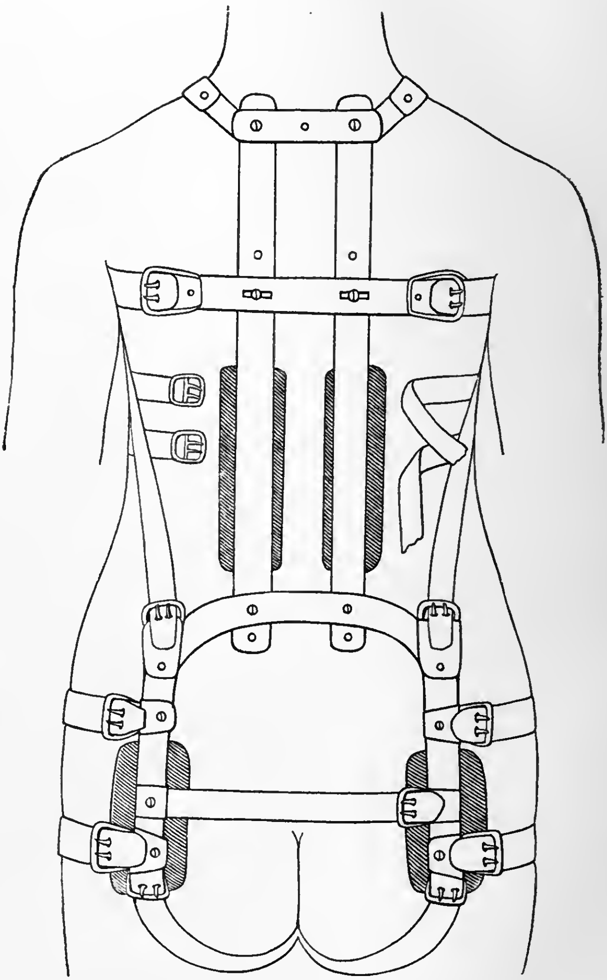


FIG. 93.—C. F. Taylor's Antero-Posterior Support for Spinal Disease (Bradford and Lovett).

joined together by an inverted U-shaped piece of steel which runs as far down on the buttocks as possible without reaching the chair or bench when the patient sits down,—that is, they must not extend down as far as the tuberosities of the ischia; or the brace may end in a waistband. The uprights are joined above by another U-shaped piece, the upper end of which passes over to the anterior aspect of the shoulders, or rather to the root of the neck. In most cases a cross bar at the level of the axillæ should be added.

"The uprights should be far enough apart to lie upon the transverse processes of the vertebræ, and not the spinous processes. They are bent according to a cardboard tracing of the back taken as described and then adjusted. The neck and bottom pieces are cut out in cardboard in pattern. The whole should then be riveted together and tried on the patient, who is lying on his face, any alterations being made with wrenches. The brace can be wound with strips of canton flannel, faced with hard rubber, or covered with chamois leather.

"Accurately fitting pad-plates covered with felt and leather or hard rubber are needed. Buckles are required at the end of the neck-piece at a level with the axilla, opposite the middle of the abdomen, and at the lower end of the brace.

"If properly designed, the appliance will press firmly at the deformity, that is, the pad-plates and pressure should be uniform at this point, and closely fitted to the contour of the deformity in all planes. The appliance will also touch necessarily at the top and bottom, but the chief pressure should be at the kyphosis. It is of importance that the apparatus be stiff enough not to yield, as the weight of the trunk falls upon it, inasmuch as yielding involves intervertebral pressure. The patient should be seen often enough to keep the brace fitting accurately, as the deformity may increase or diminish at any time.

"It is, of course, essential that the trunk be properly secured to the brace. This can be done by means of an apron which covers the front of the abdomen and chest, reaching from the clavicles nearly to the symphysis pubis. The apron is provided with webbing non-elastic straps, which are fastened into buckles attached to the brace. Padded straps, passing from the top of the brace around the arms under the axillæ, and attached to buckles in the middle of the brace, help to secure it. The apron must also be furnished with straps at the top which pass over the shoulders to buckles at the top of the brace.

"In dorsal disease some unyielding rigid chest-piece is necessary. Taylor's chest-piece (Fig. 94) acts by means of hard rubber pads at the upper part of the chest, connected by a steel rod which keeps the brace closely applied against the back. The brace should be worn day and night, and removed daily so that the part may be bathed, rubbed with alcohol, and powdered. On no account should the patient sit erect" (without it).

Dr. Judson formulates a general rule which may serve as a guide in the treatment of Pott's disease in a rigid apparatus. The rule reads: "The apparatus may be considered as having reached the limits of its efficiency when it makes the greatest possible pressure on the projection, compatible with comfort and the integrity of the skin."

In disease of the lumbar region, and if the brace shows a tendency to ride up in disease of other regions, padded perinæal straps should be added, which are attached to the apron in front and to the lower end of the brace behind. A difficulty also arises in treating cases of Pott's disease, with lateral deviation, by this method, and the difficulty is more apparent when the child sits up than when he lies down. It is therefore best to keep such patients in a recumbent position without any mechanical support until the deformity improves.

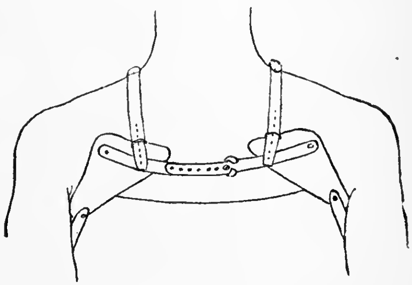


FIG. 94.—Taylor's Chest-piece (Bradford and Lovett).

In the upper dorsal and cervical region it is essential to prevent the weight of the head from falling upon the diseased bodies of the vertebræ. Taylor of New York has devised an ovoid steel ring (Fig. 92) which passes round the neck, so made that it can be opened, and is arranged so that it can serve as a rest for the chin, and support the head beneath the occiput. The head support should be used in all cases of diseases at or above the eighth dorsal vertebra.

"If[1] the brace is applied before the stage of deformity it should follow the exact shape of the spine. But if deformity is present, particularly in the dorsal region, it should be made somewhat straighter (Fig. 95) in order to permit a gradual correction of the compensatory lordosis in the lumbar region, and give increased leverage above the deformity."

It must be recognised that the continued use of supports to the chin causes recession of the part, and sometimes to such an extent

[1] Whitman, *Orth. Surg.* 2nd ed. p. 77.

that the teeth in the upper and lower jaws do not meet adequately.[1] The exact cause has not been ascertained. A condition quite the reverse of this, and also inexplicable, is the protrusion of the chin and the gradual development of prognathous jaws in severe deformity of the dorsal and cervical region in cases where the head has not been properly supported.

The Steel Spinal Support.—This apparatus is largely used in the author's practice. Its structure is seen from the accompanying illustration (Fig. 95). The first essential is a good base of support, which is afforded by a well-fitting and accurately adjusted pelvic band, so arranged that it can be opened in front. The band has fixed to it two pieces of steel, each arching over on either side from just in front of the anterior superior to the posterior superior spines. At the centre of the pelvic band posteriorly a double steel upright, *b*, is fixed, which reaches above to a little below the level of the line joining the spines of the scapulæ, thence two transverse steel bands pass outwards to beneath the axillæ. In order to ensure sufficient rigidity, two lateral steel uprights pass from the pelvic bands and are joined to the upper transverse bands just below the axillæ, and end

FIG. 95.—The Taylor Brace and Head-support and Chest-piece (Royal Whitman).

[1] Wallace Blanchard, *Trans. Amer. Orth. Assoc.*, May 1898, has designed "a brace for cervical spondylitis" which does away with the objections to most forms of head supports. "The brace is made by supporting a large pad, shaped in an occipital socket, in which the head, when held by a strap passing round the forehead, will be immovable. This pad rests on an arch formed by the joining of two steel rods, passed down over the posterior face of a leather shell-back brace, and these are secured in such a manner as to be raised or lowered to any desired position, and there held by set-screws. The leather

in horned and pear-shaped extremities. They lie between the coracoid processes and the heads of the humeri. The utility of the apparatus depends upon an accurate fitting, which is made while the patient is suspended, and when it is removed at night the patient ought to be lying down. It is replaced in the morning, before the patient rises from the horizontal position. The posterior uprights lie exactly in the lines of the transverse processes, and there must be no pressure on the spinous processes nor on the ribs. The uprights are made so that they just fall short of exactly following the curves of the vertebral column, thus exercising a lever-like action as in the Taylor brace. When the posterior deformity is small and the vertebræ are not fully ankylosed, advancing plates may be fitted to the uprights so as to bring moderate pressure to bear on the transverse processes at the projection. The main object of the apparatus is to exert antero-posterior leverage on the spinal curvature, exactly in the same way as if one stands behind a healthy person and puts the arms and hands beneath the subject's axillæ, and exerts backward traction. The effect is that the subject is absolutely prevented from flexing his spine. To cover the chest and abdomen, stay material with lacing down the front is used, and further,

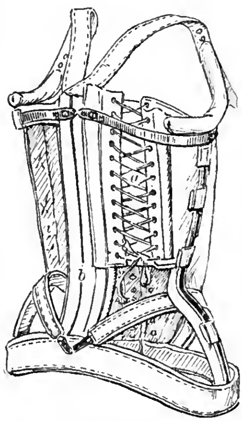


Fig. 96.—Laced Shield Spinal Apparatus. The steel spinal support, used by the author.

splint is firmly and accurately adjusted to the body and securely laced to it; and the occipital pad should then be in a position so far posterior and above a level with the occiput that considerable force is required in lifting and carrying backward the head, so as to place the occiput on the pad, and with the chin elevated. The occipital pad serves as a fulcrum on which to rest the head." The chin is unsupported and, therefore, escapes pressure, and the fish-mouth appearance is avoided. Further, Blanchard's support is designed to obviate the great disadvantage from which all chin-rests suffer, viz. that when the patient attempts to open the mouth, the resistance of the chin-piece prevents depression of the lower jaw, and the upper jaw is raised by throwing the head backwards. Another interesting article by the same author is a paper on the "Present Status of the Mechanical Treatment of Spondylitis," read before the Chicago Orthopedic Society, March 30, 1904. A review, with criticisms of the various methods of treatment, is given in a series of lectures published by Ridlon and Jones in the *Philadelphia Medical Journal*, No. 18, p. 777 *et seq.* The late Dr. A. M. Phelps delivered a lecture before the New York Post Graduate Society (*N. Y. Post Graduate*, 1899, pp. 157-186) on "A Consideration of Tuberculosis of the Spine and Lateral Curvature, with Reference to Ancient and Modern Supports."

if the disease is above the eighth dorsal vertebra, a head support with a chin-piece is added. This apparatus acts on the same principle as the Taylor brace, and answers equally well. In most cases of spinal disease, when the patient walks about it is well to supply him with rubber heels to diminish concussion.

The Advantages and Disadvantages of the various Forms of Supports.—In early childhood it is difficult with either plaster or steel supports to secure efficient fixation at the pelvis, as this part of the skeleton is feebly developed, and the difficulty is greater with plaster than with the steel support. If the disease be low down, at the lumbo-sacral junction, for example, the steel support is better than the jacket, as the former can be carried lower down, and be more closely fitted. And, when it is necessary to support the head it is wiser to use a steel brace than plaster, because of the better attachment for the head-piece. A plaster of Paris jacket is most useful in disease of the spine from the tenth dorsal to the third lumbar vertebra. It is also more easily worn if lateral deviations of the spine exist, and above all, its cheapness places it within reach of the poorest. Bivalve plaster jackets are not to be recommended, for the lateral straps allow too much play.

In disease of the cervical vertebræ, after the head and chin support has been discarded, a collar of poroplastic felt or of leather is often used.

Psoas-Contraction.—Spinal disease in the lower dorsal and lumbar regions is frequently complicated by psoas-contraction, and its persistence causes any apparatus to fail in the objects desired. It prevents that erect attitude so essential to consolidation in the best position. When allowed to persist and increase, it renders all apparatus ill-fitting and uncomfortable by pressure and friction. The best means of treatment then is rest in bed with weight-extension to the lower limbs, and counter-extension to the head and neck. Continuous psoas-contraction is a sign of progressive disease, and is frequently a precursor of abscess. In any case, before an apparatus is fitted the psoas-contraction ought to have disappeared, and in some instances, in addition to weight-extension, it is necessary to divide the secondarily contracted adductor tendons and those attached to the anterior superior spine and its neighbourhood. It is only in very exceptional cases that sub-trochanteric osteotomy[1] is called for.

When may Treatment be dispensed with in Spinal Caries?—1. The absence of pain is no test, since it naturally ceases after a

[1] Bradford and Lovett, *Orth. Surg.* 3rd ed. p. 81.

period of recumbency, and no support ought to be fitted if there is pain. If pain ensue on removal of the support, the jacket must be put on again, or better still, the patient should rest for a time.

2. When the spine is firmly fixed and the deformity has remained stationary for some years.

3. Dorsal caries is never cured in one year, but requires three years; cervical and lumbar may require less.

Immediate Rectification of the Deformity by Rapid Correction.—A clear distinction must be made between the methods which have been used. In immediate correction, as the name implies, the object is to dispose of the deformity at one sitting. Another method is gradual reduction, where the correction is carried out in successive stages at suitable intervals, and with carefully regulated pressure.[1]

Immediate correction was introduced during the preceding decennium by Calot of Berck-sur-Mer, although it is to Chipault that the revival of an old method is due. It should be added, by way of parenthesis, that Chipault's procedure differs from Calot's in that the former, after reduction of the deformity, wires the spinous processes together with the object of preventing recurrence of the deformity—a vain hope, as it is impossible to expect wire, however strong, to be capable of neutralising the forward leverage of the upper part of the body, the shoulders, head, and neck.

It has been demonstrated by many observers and operators that immediate rectification can be carried out in suitable cases without much serious risk to the patient; it often proves a comparatively painless operation, some of the cases having been done without an anæsthetic, and the patient has not complained either of the pain of traction or of pressure on the spine. Results have been collected by Bradford and Vose of 610 corrections, and by Bradford and Cotton of 639 operations.[2] In the 610 cases 21 deaths, immediately due to the operation, occurred; and among the accidents, hæmorrhage, rupture of the pleura, rupture of abscess, fracture of the spine, and paralysis took place, following excessive violence or the employment of the operation in unsuitable or hopeless cases.

Mr. Robert Jones and the writer operated upon 25 cases from June

[1] See footnote, pp. 169-170, for this reference.

[2] E. H. Bradford and Vose, *Trans. Amer. Surg. Assoc.*, 1899; and Bradford and Cotton, *Boston Med. and Surg. Jour.*, Sept. 20, 1900.

to September 1897,[1] and showed the immediate results in November of that year to the Clinical Society of London. In fulfilment of a promise given, they detailed the results, and showed most of the cases two and a half years afterwards to the same Society, and they gave their experience of 74 other cases, making 99 in all. Of the original 25, 5 were dead at the date of the second communication—3 of non-spinal tuberculosis, 1 of diphtheria, and 1 of intestinal obstruction. Four cases discontinued treatment, 4 developed abscess, and 1 became paraplegic eight months after the operation, but had since recovered. In 5 cases, paralysis was relieved by the operation, and in 5 other cases the spinal deformity disappeared and remained so with the assistance of a spinal support, whilst in 10 cases the angular projection was much lessened.

Comparing these 25 cases with 25 control cases not operated upon, they found that the results of operation were by no means discouraging. The second series of 74 cases[2] yielded the following results: 29 were walking about, 28 were recumbent, 10 had discontinued treatment, and 7 died. Taking the two series of cases, they found that during two and a half years 12 had died; 15 had discontinued treatment; 44 were walking, some with and some without supports; and 28 were recumbent; 17 developed abscess, and in 11 of these the abscesses had opened and closed; 12 had recovered from paraplegia, and 6 were still ill from tuberculosis. In 44 cases the curvature was obliterated or improved. In 16 cases the curvature was not improved, and 15 patients had discontinued treatment.

During the last six years immediate rectification or reduction at one sitting has fallen into disuse, and we ourselves early ascertained that reduction by successive small rectifications was the better course to pursue. Indeed, many of our cases alluded to above were treated in this way, and they did well, provided that they were closely watched and the spine was carefully supported.

Cure in Pott's disease is brought about by partial replacement of the diseased tissue by new bone, and this takes place if time is given, and the reparative process is not overwhelmed by the destructive process. When a large deformity is suddenly obliterated, the cicatricial products must be injured or torn through, and this, to say the least, delays consolidation and invites recurrence of the deformity; which is due to two causes. At the time of operation a gap is left at the site of disease between the bodies, and no convincing evidence has been adduced to prove that a space of

[1] "Cases of Immediate Reduction of the Deformity of Spinal Caries," by R. Jones and A. H. Tubby, *Clin. Soc. Trans.* vol. xxxi. p. 19.

[2] *Clin. Soc. Trans.*, 1900, vol. xxxiii. p. 152. By a misprint in p. 155, line 6, of that communication, "In 4 cases the curvature has been obliterated or improved" should read "44."

large size is completely filled up by cicatricial osseous tissue. Even if it were, some of the deformity will recur, because the new bone does not increase *pari passu* with other parts of the spine, and irregularity must follow as the child grows. Another cause of recurrence is the difficulty with out-patients of ensuring that continuation of recumbency and the use of supports over a number of years, sufficient to allow of the formation of new bone around and within the area of separation of the diseased vertebræ. Immediate reduction was introduced with the object of rapidly reducing the deformity, and the presumption was that the reduction could be maintained afterwards in the upright position. In the latter respect it has, in the writer's opinion, failed in the majority of cases. The method has also fallen into disuse because accidents have occurred, such as hæmorrhage, rupture of abscess, respiratory embarrassment and failure, dissemination of acute tubercle, and paralysis. Some of these accidents were undoubtedly due to operating upon partially or entirely ankylosed cases. In recent cases without abscess [1] there is little or no danger to the patient.

Whilst the immediate and rapid operation [2] has been abandoned even by Calot and his followers, yet we have learnt two important lessons. How often it happens that a method designed to carry out a certain purpose fails in its immediate results, yet opens up ways for improved treatment of disease or deformity in other directions! The lessons we have learnt from immediate reduction are: first, that when deformity exists we need not stand by with tied hands, but we can reduce the deformity without roughness and gradually; and, second, we have also been taught to appreciate the extreme value of hyper-extension of the spine in all forms of the treatment of Pott's disease. The surgeon must neither allow deformity to appear under treatment, nor if it be present, without ankylosis, must he allow it to become exaggerated. On the contrary, he has it in his power to lessen it. And even in ankylosed cases, especially in the dorsal region, he may make it appear less by increasing the normal forward curves of the lumbar and cervical parts of the column.

To the credit of Chipault and Calot must be placed this point. By their operation more cases of paralysis were relieved than by other means, except by absolute and entire rest. The results of forcible and immediate correction in the treatment of paralysis

[1] During the years 1897 to 1900 skiagraphy had not been so perfected as it is now. It was not then possible to ascertain by this means the existence of abscesses.

[2] A description of the method is to be found in the *Clin. Soc. Trans.*, 1898, vol. xxxi. p. 20.

are greatly superior to those obtained by laminectomy. As the rapid method of reduction has been abandoned, and been replaced in the hands of some surgeons by correction in stages, it is not therefore necessary to describe the older procedure.

Gradual Correction of the Deformity.—In all non-ankylosed cases one of the objects of treatment, whether by recumbency, or supports either of plaster or in the form of steel apparatus, is to diminish the deformity. Hence many jackets are fitted whilst the patient is suspended from a tripod, or lying prone and extended in a hammock, as originated by Richard Davy of the Westminster Hospital. Realising that the same results can be attained by steady and continuous correction without the risks attendant upon the forcible and rapid method, surgeons have devised

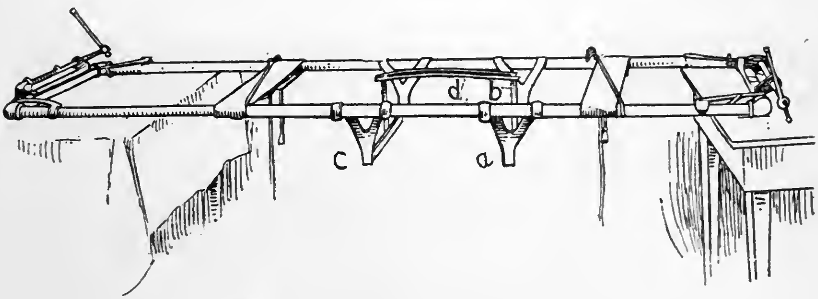


FIG. 97.—Goldthwait's apparatus for Gradual Correction of Spinal Deformity. (For explanation of the lettering, see the text.)

means which work admirably. They are two in number, and they have this feature in common: they depend for their efficiency upon extension and hyper-extension of the spine. One method, and that most commonly in use in America, is by the employment of Goldthwait's extension frame;[1] and the other is by the extension couch and traction of weights to the head and legs, followed by the use of a steel spinal support, with advancing plates fitted to the back levers. Selection of cases must be made for the continuous and steady methods; the most favourable are the recent, especially in children, without abscess.

Steady Correction by Goldthwait's Apparatus.—The following is a verbatim account from his article:—

"The apparatus consists of a strong gas-pipe frame, six feet long by two feet wide (Fig. 97). Suspended from this is a bar (a), in the centre

[1] *Trans. Amer. Orth. Assoc.* vol. xi. p. 95.

of which is a vertical rod (*b*), forked at the top, and long enough to reach to the level of the frame. This cross-bar is simply suspended from the frame so that its position can be changed as desired. Below this is another cross-bar (*c*), which rests on the frame and can also be adjusted as to position. Upon this latter piece (*c*), and upon the fork of the rod (*b*), rest two malleable steel bars (*d*) about eighteen inches long. These rest in grooves one inch apart, and should be bent to conform partly with the lumbar curve of the spine, after which they are heavily padded with felt and the patient laid upon them. The upper end of the bars (*d*) should just rest upon the fork, not projecting over; and when the patient is in position, the rod should be one inch above the apex of the deformity, and the buttocks rest upon the cross-bar (*c*), and the legs are supported by one or more heavy webbing straps which can be tightened or loosened at will. No support whatever is given to the upper part of the body, except that the head is steadied by the surgeon with the hand, until a satisfactory amount of correction has been accomplished; and

Fig. 98.—The patient lying upon Goldthwait's apparatus, with the Spine hyper-extended.

then a strap similar to those used below gives the support, so that the operator's hand is free. If traction is desirable, it can be applied by means of a windlass which is attached to each end of the frame. This makes it possible to obtain much more definite and steady traction than would be possible with assistants, but its use has not been found necessary in the majority of the cases, simple over-extension of the spine accomplishing the same results.

"When the maximum over-extension that is desirable is obtained, the strap under the head is fastened, and the patient allowed to lie in this position until the plaster jacket is applied (Fig. 98). In applying this, the iliac crests should be generously padded with heavy felt, and a similar pad should be placed over the upper part of the sternum, so that the jacket can be carried high up to prevent the upper part of the body with the shoulders from drooping forward. In the cases with disease in the upper dorsal region, the jacket should be moulded about the anterior part of the neck, so that an erect position of the head is necessary. The forked rod (*b*) is easily avoided by a few figure-of-eight turns of the bandage, so that when the plaster has set, the patient can easily be lifted off; and as the rod (*b*) should be placed one inch above the apex of the deformity, this weak spot in the jacket is not objectionable.

"When the patient is taken off the frame, the two rods (*d*) are slipped out from below, leaving the pads in place.

"As a matter of experience it has been found necessary, practically always, to cut a small window over the point of greatest deformity, as otherwise when the body settles down, as is inevitable, a slough will form even though a liberal amount of padding has been used. This procedure is repeated from time to time until the best possible attitude has been obtained."

A simpler and a more portable frame is figured here (Fig. 99).

The second method of securing gradual recession of the deformity is by placing a convex pad beneath the diseased area while the patient is recumbent. Horizontal traction is made at the same time on the head, arms, and legs by weights. If he be suspended

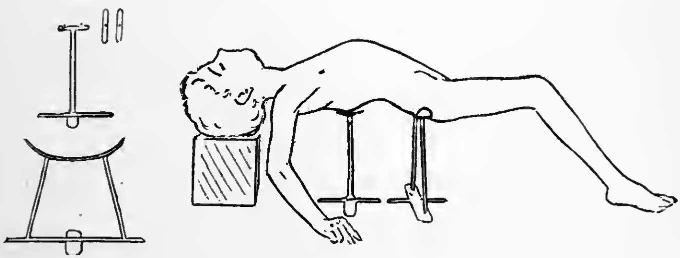


FIG. 99.—Goldthwait's Portable Frame, for the application of a plaster-jacket.

on the spinal frame from the head and axillæ (Fig. 67, p. 143) the pillow is fixed so as to support the curvature. A third method is by Lorenz's plaster bed (Figs. 82, 83, 84).

As to the length of time required to effect a satisfactory reduction in the deformity, it will certainly be not less than one, and in most cases two years. In the after-treatment much care is required to prevent relapse. The usual causes of recurrence are leaving off supports too soon, or continuing to wear an ill-fitting one.

Correction, thus gradually applied, is beneficial and successful in all cases of active disease. It often prevents abscess and compression-paraplegia, and arrests or removes deformity. Pressure on and displacement of the viscera and kinking of the great vessels, which cause debility and shorten life, are obviated.[1]

[1] On the subject of "Redressement of the Spine," or "Reduction of the Deformity," the following articles may be consulted. Bradford and Cotton (*Boston Med. and Surg. Journal*, Sept. 20, 1900) have analysed the literature and collected the results of 639

Even after the cure of the spine is complete, and no further settling down can be observed, the patient suffers from neuralgic pains due to depressed health or to physical causes, such as the pressure of the last dorsal nerve between the twelfth rib and the crest of the ilium. Goldthwait has practised resection of a portion of a rib successfully in several such cases.

Other Operative Procedures on the Diseased Focus.—If pus be suspected, it may be deemed advisable to expose the affected vertebræ. In the neck this can be done through the posterior triangle, in the dorsal region by Ménard's operation of costo-transversectomy, in the lumbar region by an incision through Petit's triangle, and dissection down to the psoas muscle and spine. It is essential, however, to grasp the facts that these operations are not routine procedures, and can never be recommended as such. Even if they are carried out for the removal of diseased bone the result is almost invariably failure, for appreciable sequestra rarely form in tuberculous caries; and the author has seldom found pieces of dead bone larger than a pin's head, certainly not so large as a pea, in the pus from a spinal abscess.

The efficacy of vaccination with tuberculin for Pott's disease is still *sub judice*. We must refer the reader to pp. 35-42, which deal with this form of treatment for osseous tuberculosis.

Duration of Treatment in Uncomplicated Spinal Caries.—Successful treatment extends over years. It cannot be measured by months. Cessation of pain, apparent restoration to health, and ability to get about are not synonymous with cure, for the disease is often stealthily progressive, and deformity slowly increases. We must recognise that there are two stages in the history of spinal disease, viz. that of ulceration with destruction, and that of healing.

cases operated on after Calot's method. The figures are instructive; cf. also article by Bradford and Vose, *Ann. Surg.*, Nov. 1899. Ménard (*Étude pratique sur le mal de Pott*, Paris, 1900, p. 349 *et seq.*) criticises Calot's original and his more recently modified method, exhaustively and ably. Max David, *Grundriss der orth. Chirurgie*, p. 85 *et seq.* R. Tunstall Taylor (*Johns Hopkins Hospital Bull.* vol. xii., Feb. 1901, No. 119), "Hyper-extension as an Essential in the Correction of the Deformity of Pott's Disease, with the Presentation of Original Methods." Rédard, *Traitement des déviations de la colonne vertébrale*, Paris, Georges Carré et C. Naud, 1897. Chipault, *Manuel d'orthop. vert.* p. 65 *et seq.* Wullstein, *Zeitsch. f. orth. Chir.* Bd. xii. 4, 1904, and "On the Anatomical Changes produced by Forcible Rectification in Pott's Disease of the Spine," *Arch. für klin. Chir.* Bd. lvii. p. 485. Lange, *Wiener Klinik*, Heft 1, 1899. Calot, *La Semaine médicale*, Dec. 23, 1896, also *Acad. de méd.*, June 8, 1897. Chipault, *Journal de clin. et de thérapeut. infantile*, Feb. 11, 1897. Calot, *Lancet*, Dec. 4, 1897. Kirmisson, *Difformités acquises*, p. 52.

They are not necessarily distinct, for in a large focus, or if multiple foci are present, the processes may go on simultaneously in the spine. More often, healing does not commence until ulceration and destruction have ceased, which does not occur until at least one year after the beginning of the illness. Healing requires at least another year, generally two years, and frequently longer, even in uncomplicated cases.

It is therefore manifest that great care is required for at least two years, and in many cases much longer. In order to ensure an entirely satisfactory result, viz. cure of the disease without the formation of a projection, recumbency and supports must in the case of children, adolescents, and young adults, be employed throughout the period of growth.

To *sum up* the treatment of uncomplicated tuberculous caries —all early, progressive, and relapsing cases demand complete recumbency with extension for at least twelve months and in the open air. This is the only way of avoiding complications such as deformity, abscess, and nerve-lesions. A moderate degree of hyper-extension with traction is always desirable for reasons fully detailed. The general health requires attention, and the desirability of vaccination with tuberculin must be considered, although so far it has not been so satisfactory in tuberculosis of the spine as elsewhere.

When pain has disappeared, if no deformity is present, if the temperature has been consistently normal for some months, if the child has gained weight and is restless on his couch, and if on trial it is found that the back is firm and unyielding, then the child may be gradually raised on the couch, and later may assume the upright sitting position in bed with the spine supported. He may then be allowed to walk about, at first for a few minutes a day, wearing a suitable support, at all other times being recumbent. Gradually the period of activity is increased and that of rest shortened. All patients who have suffered from tuberculous caries require one to two hours' rest a day; and if they fail to secure it, they suffer from fatigue and backache, even when the diseased area has been healed for a long time.

The Treatment of Spinal Abscess

Abscess complicating Pott's disease constitutes a grave source of danger to life. There can be no doubt that abscess and its sequelæ are the most frequent cause of death in spinal caries. In gravity it may vary from a small collection of pus coming to the surface as directly as possible from the site of bone disease and readily amenable to treatment, to enormous cavities containing pints, and extending beneath muscles and between planes of connective tissue in so devious a manner as to baffle all attempts at radical treatment. When the latter burst they form several discharging sinuses. One or more of them occasionally heal, and a new outlet is formed for the pus at some other spot, perhaps not so favourably situated for drainage and asepsis as the previous opening. There are few types of cases so formidable to the surgeon.

Clinically, a clear distinction exists between an unopened and a discharging abscess. The former is sometimes well borne, and we may assume that the dose of tuberculous toxin absorbed is small, for the abscess itself is small and is only discovered by chance. In fact the focus in the spine is itself an abscess, and the size and migration are in direct correspondence with the patient's movements, the virulence of the disease, and the amount of destruction. More often the patient's appearance leads to a search for pus. The opening of an abscess, whether spontaneously or not, is a serious matter. It has been clearly shown that in the contents of many unopened abscesses tubercle bacilli alone are present. Septic contamination occurs when the pus is close to the viscera, when it reaches the skin, or if infection is introduced at the time of operation or at the after dressings. Pure tuberculosis is thus transformed into tuberculosis and septic intoxication, or mixed infection. If long tortuous sinuses have formed, and where there is much spinal "denudation," the septicæmic or hectic condition is indefinitely prolonged, and ends in lardaceous disease, emaciation, and death from progressive weakness. In cases with short sinuses, as in cervical tuberculosis, mixed infection is not badly borne, and the sinuses often heal.

Therefore we have to decide in a given case, in which pus is present, whether we shall operate or not. The author's views have undergone considerable modification during the last ten years. An extensive experience has taught him that a large proportion of abscesses, or rather the fluid contents of them, disappear more often than is thought. As many abscesses absorb and remain as inert calcareous masses, and many if opened become septic, delay in operating upon them is strongly advocated. We must place the patient entirely at rest and in the best conditions possible, until our hands are forced by the imminence of spontaneous rupture through the skin, with the risks of sepsis; or the relief of pressure upon the spinal cord may demand interference.

The methods of treatment open to us are—

1. *The Expectant Treatment.*

2. *Surgical Interference*, either by aspiration, or aspiration with injection of bactericides, or incision with or without drainage. And under this heading must be included attempts to reach the source of mischief in the spine itself.

1. The Expectant Treatment.—There is no doubt that complete recumbency assists in the absorption of some abscesses. So long as the patient is doing well, the abscess is diminishing in size, and he can command the best hygienic surroundings, there is absolutely no need for operative treatment. Even if the abscess, especially if it be a psoas or lumbar one, is increasing in size, we do not counsel interference, if the temperature remains normal and the general condition is good. These patients are best kept recumbent in the open air, and in the course of a few months the pus will often make its way into the groin and the thigh, and the channel communicating with the spine become closed. Nevertheless, the expectant treatment must be discontinued if an intermittent temperature is observed, or if the abscess, coming to the surface, is causing congestion of the skin. Mr. Robert Jones,[1] of Liverpool, favoured spontaneous opening of the abscess, or a small incision just when it is about to burst, the site of the opening in either case having been previously sterilised, and then covered with an aseptic dressing,[2] and he says that "after spontaneous opening the sinus closes more readily, and septic infection of the track is less likely to occur." The statistics of Messrs. Jones and Ridlon[3] are encouraging from this point of view.

[1] Jones and Ridlon, *Prov. Med. Jour.*, Dec. 1892.

[2] If septic infection is to be prevented when the gush of pent-up pus from a large abscess happens, then the area of skin sterilised must surely be very extensive, and the dressing very large.—A. H. T.

[3] *Loc. cit. sup.* and *Philad. Med. Jour.* No. 18, p. 777 *et seq.*

Of 65 cases of abscess, in 42 the results were:

16 disappeared spontaneously.

10 are diminishing.

15 opened spontaneously or were incised when just about to burst. Of these—

2 closed in 10 days;

4 closed in 3 months;

3 closed within one year;

6 are still discharging after a period of two to three years.

1 died from exhaustion.

Mr. Robert Jones is an experienced and careful observer, and his views, although they differ from those of most surgeons on this point, are entitled to great respect.

The *indications* for the expectant treatment are—

(1) When the abscess is apparently single, and not tracking in two or more directions.

(2) When the recumbent position is immediately followed by cessation from pain and improvement of the general health.

(3) The expectant plan should be persevered with, if after a short trial the abscess ceases to enlarge.

(4) A large collection of pus is no hindrance to the trial of this method, provided that the appetite is good and the temperature is normal—in fact in those abscesses which were formerly designated as "cold."

(5) If it is evident that pus is near the skin and pointing, it is better to open aseptically and so avoid the risks of spontaneous opening.

2. Surgical Interference: A.—**Aspiration**, either on one or several occasions, has proved of some permanent value, but the caseous matter and *débris* of disease are left behind, and fluid may re-accumulate with great rapidity. Very rarely a single aspiration is followed by disappearance of the abscess. Repeated aspiration sometimes proves successful.

Aspiration succeeded by injections of sterilised iodoform suspended in glycerine, or of small quantities of iodoform dissolved in ether, sometimes gives rise to poisoning, or is followed by great distension of the sac and acute pain, and is now being abandoned. Ménard[1] used a mixture of naphthol and camphor in some hundreds of cases with benefit, but gave it up after two deaths. He now employs a

[1] *Op. cit. sup.* p. 380 *et seq.*

mixture of thymol 1 part and camphor 2 parts, which makes an oily fluid. He claims that it has a solvent action on the fats of which the abscess contents are largely composed, and excites a favourable irritation of the abscess walls. He says that the lumps of semi-solid stuff which fail to come through the trochar at the first or early punctures become disintegrated and dissolved by the injection-material, and at subsequent punctures run through the trocar as a solution or emulsion. He adds that the abscess wall instead of being soft, œdematous, grey or pale pink, with caseous patches in it, gradually takes on the characters of healthy granulation tissue. The procedure involves aseptic puncture, evacuation of pus, lavage with boracic acid solution, and injection of 10 to 25 grammes of the thymol-camphor mixture. He finds that the abscess fills up in 2 to 5 days, and repeats the operation in 8 to 20 days. After each evacuation the liquid becomes less lumpy, and is soon ropy and albuminous, which Ménard claims is a sign of the good effect of injection. He adds, by way of parenthesis, that "abscess walls which bleed readily get well quicker." As a rule, two or three injections suffice to cure the abscess. If temporary fistulæ occur, the greatest care must be taken to keep them aseptic, and they heal up in two to four weeks. The procedure of Ménard has been given in full because of his vast experience and the admitted soundness of his views and methods.

B. **Incision with or without Drainage.**—By this is meant opening the abscess, evacuating the contents, and draining or attempting to secure primary union. The principles, in the author's opinion, which should guide the surgeon when he has an abscess to deal with, and feels that he may be compelled to operate sooner or later, are the following, especially in dealing with psoas or pelvic abscesses:—

(*a*) Let the patient remain recumbent, and if the abscess is increasing, allow it to make its way as much as possible into a place where it may be reached easily, *e.g.* allow a psoas abscess to come well below Poupart's ligament into the thigh. The track in the abdomen may and often does become shut off, and even be healed before it is necessary to evacuate pus.

CASE 8.—*Spinal Abscess, Burrowing into Thigh and Evacuated there. Good Result.*—A girl, aged 8 years, was admitted to the National Orthopædic Hospital on 19th December 1893, with a posterior projection of the spine extending from the tenth dorsal to the first lumbar vertebra. A large abscess was felt in the right iliac fossa. It reached internally as far as the umbilicus, and fluctuation was felt on the outer side of the femoral artery in Scarpa's triangle. She was placed in bed, extension applied, and she was given cod-liver oil. On 2nd February 1894 the abscess was found to have diminished sensibly, and did not extend beyond the mid-point of a line drawn from the anterior superior iliac spine to the umbilicus, with corresponding decrease in other dimensions. The child became fat and ruddy, and put on fifteen pounds in weight. In October no fulness or fluctuation could be felt in the iliac fossa, but a large collection of pus was found at the outer and posterior aspect of the right thigh. This was opened in three places on the outer side of the thigh, the sac carefully cleansed and rubbed out with iodoform emulsion. Healing by primary union took place. About one drachm of pus re-formed beneath the incision at the middle of the thigh. The fluid was let out and the wound closed. She was seen by the writer twelve years subsequently; another abscess has formed, which is being dealt with on the same lines.

(*b*) Place the incisions as far as possible from sources of contamination. By waiting and allowing the pus to track down this can often be managed.

(*c*) Single incisions into abscesses of any size or complexity are hopeless. At least two if not three openings are required. With a single incision into a psoas abscess free evacuation from remote corners is prevented, because the pressure of the air in the opened sac holds back the pus and caseous material. Squeezing does not obviate this, as it is often impossible to press the sac evenly near the spine and systematically extrude its contents. One incision must be near the source of the mischief, and at least one, if not more, at a distance.

(*d*) Endeavour to get primary union. After satisfying himself that the cavity is clean and dry, the surgeon sews up the incisions at once and allows the skin to heal, so securing primary union and avoiding the risk of infection. In a few cases the primary union remains sound, whilst in many others a small quantity of serum, or serum and pus, forms beneath one of the incisions. It can be aseptically evacuated by making an opening with a probe a few days later, and the wound generally heals firmly.

(*e*) Always apply firm pressure with pads along the track of the abscess.

(*f*) Asepsis from the first incision until every drop of pus has ceased to flow is the prime necessity; and let the surgeon always remember that slips in aseptic technique will probably cost the patient his life. The one thing to be avoided is septic infection of the sac, and it is nearly impossible to get it sweet again. So that it is no light responsibility to perform the "simple" operation of opening a spinal abscess.

(*g*) Remember that recumbency in the open air always assists the disappearance of abscess.

We may now discuss the various methods of dealing surgically with abscesses in general, reserving till later the consideration of special forms of abscess. Barker's method, now well known, is often employed. There is a difference of opinion as to the value of curetting the sac-wall. Most surgeons employ it, but Robert Jones [1] has found it better, when opening a psoas or lumbar abscess, to proceed thus: "The abscess should be opened, the vertebræ explored for sequestra, and the cavity wiped out and scraped gently with the finger covered with perchloride gauze, the ends of which are held in the palm by the other fingers, when a slight general oozing of blood takes place which soon stops. The cavity should next be washed out with hot boracic acid solution. It will be found that the chronic abscess wall, after gentle rubbing, collapses rapidly. Deep sutures should be used for the quadratus and erector spinæ, and the superficial wound should be closed. The whole cavity becomes obliterated by organisation of blood-clots, which may fill the original abscess cavity, now much collapsed. Before stitching has commenced, firm pressure is applied by an assistant pressing forcibly with both fists over the course of the track, and then the hand pressure is replaced by firm pads and bandages." Mr. Jones is absolutely opposed to energetic scraping away of the abscess wall with a spoon or the flushing scoop of Barker, on the ground that the "lining membrane of the abscess cavity, with its envelope of fibrous tissue, is an admirable protective against general infection." Ménard, however, advocates thorough curetting.

The value of the injection of various drugs, such as iodoform in glycerine, or menthol dissolved in spirit and suspended in glycerine,[2] is difficult to determine. After a long experience with them, I have regretfully come to the conclusion that they have not much effect. All irritating drugs, such as carbolic acid solution, perchloride or iodide of mercury, are dangerous. On one occasion I saw a patient become extremely collapsed on the table and nearly die from an injection of carbolic acid solution of a strength of 1 in 40; and I know of another, so treated, who died half an hour after being put back to bed.

[1] *Prov. Med. Journ.*, December 1892.

[2] Menthol, ʒj, alcohol abs., ℥j, dissolve, and suspend in glycerine, Oj.

The character of abscesses differs very largely. It may be that we are dealing with a localised abscess which is pointing, in which the spinal disease is quiescent, and the track from the spine healed; or, on the contrary, we may have to treat one which runs beneath fasciæ, has numerous pockets connected with it, overflowing from time to time into the main cavity through minute openings; or, finally, some may be almost entirely pelvic. The localised forms are readily dealt with, and do well. Of the others, at the best, the outlook is doubtful.

Sites of Incision for Spinal Abscesses.—Cervical abscesses are best opened from the side of the neck at the posterior border of the sterno-mastoid or the anterior border of the trapezius, unless there is urgent dyspnœa and dysphagia calling for instant treatment from the pressure of a retro-pharyngeal abscess. An exit for pus may then be obtained through the posterior wall of the pharynx, the child being placed face downward, or the head hanging well over the back of the table. The risk of septic infection is inevitable, and a pharyngeal opening should be avoided if possible. Dorsal abscesses should be opened where they point, generally to one side of the middle line of the back. Posterior mediastinal abscesses are best evacuated by a modification of Ménard's method of costo-transversectomy. A vertical incision is made on the side where the dulness is greater, and two or three of the costo-transverse articulations are exposed, then the portions of the ribs between the heads and angles are resected, and the transverse processes as well. The finger is then pushed along the surfaces of the vertebral bodies until pus is reached. This is usually at or in the neighbourhood of the fifth dorsal vertebra (Whitman). An opportunity is taken of removing the caseous and carious material from the spine itself, or pus may be evacuated from the spinal canal. The incisions for lumbar abscesses are made along the outer side of the transverse processes, and carried down till the sac is reached. In dealing with iliac and psoas abscesses, it is essential that the incisions be away from the genitals. In children it is almost hopeless to expect to keep the discharge sweet when the incision is on the inner side of the thigh. If fluctuation is present below Poupart's ligament as well, the openings made in the thigh in the iliac region, and the upper one in the lumbar region, must be closed at once.

Wallis[1] opened a psoas abscess by an incision as for ligature of the external iliac artery, inserted a long pair of forceps into the

[1] *Clin. Journ.*, 9th March 1898.

abscess cavity, and cut down on the end of them as far up as possible. He scraped and irrigated the cavity with perchloride of mercury solution, rubbed it with iodoform emulsion, and packed it with gauze. He then sewed up the anterior incision and covered it with collodion, and inserted sutures in the posterior incision, but left them untied. He removed the gauze in 36 to 48 hours, and tied the posterior sutures and sealed the wound.

Sir F. Treves has pointed out that the lumbar incision is not possible when deformity exists such as to bring the ribs close to the iliac crest. Nor is it easy in the case of a very fleshy patient. In any case it is wise, in dealing with children, to cover the dressings, wherever they may be, with waterproof material, to prevent external contamination.

C. **Treatment of the Diseased Spine at the Time of Opening the Abscess.**—The object of this procedure is to place the treatment of spinal abscess on the same footing as that of caries of bone elsewhere, viz. removal of the source of trouble in the spine, and thorough cleansing of the abscess cavity. In 1882, Israel[1] of Berlin, operating on an abscess in the lumbar region, removed part of the twelfth rib, scraped out the carious portion of the diseased vertebral body, and opened up the vertebral canal from which a quantity of pus escaped. In 1884, Mr. (now Sir F.) Treves read a paper before the Royal Medical and Chirurgical Society, urging that psoas abscesses should be evacuated through the loin, and he gave the steps of an operation by which the psoas muscle can be reached at the outer margin of the erector spinæ by means of a vertical incision, cutting through the sheaths of that muscle and the quadratus lumborum, so reaching the psoas. The psoas sheath is incised and the vertebræ examined by continuing the operation on the deep aspect of the muscle. In one case portions of diseased vertebræ were removed. Sir F. Treves[2] quoted three operations, after all of which the patients recovered for a time.[3] Ménard,[4] however, remarks, "As to the removal of the sequestrum itself I have never had the chance of appreciating the advantage thereof,"[5] which is curious with his wide experience.

[1] *Berlin. klin. Wochenschr.*, 1882, No. 10.

[2] *Brit. Med. Journ.*, 12th Jan. 1884.

[3] Much insistence must be placed upon the rarity of the cases in which it is possible to remove portions of necrosed bone.

[4] *Op. sup. cit.*

[5] *Cf.* Chipault, *Études de chirurgie médullaire*, p. 225. He gives statistics of cases so treated.

D. **Complete Removal of the Sac by Dissection.**—Some surgeons have attempted this and rarely succeeded. It is quite impossible in large, complicated, and migrating abscesses. Yet it may be possible in quiescent abscesses with a single track, and easily accessible. The writer has had no experience in this direction, except in those cases where a migrating abscess has become limited to the thigh.

E. **Treatment of a Discharging Abscess Track which is Infected.**—The gravity of the condition varies with the length of the track, its tortuosity, and the presence or absence of narrowings, as for example when the track passes beneath Poupart's ligament; also if ramifications exist and the pus accumulates and wells over. It may happen that a sinus on one side of the body acts as a drain for the overflow from an abscess on the opposite side. Any one of such conditions renders the case formidable, and very often all these difficulties are present. The most important thing to do is to secure the best hygienic surroundings for the patient, and his one chance is continued open-air treatment at the seaside for a long time. Cod-liver oil and tonics are useful, and if the pus appears to come from a reservoir which fills and overflows, then a free opening must be made, the sac gently cleaned, and ample counter-openings provided. Injections of antiseptics are useless. They neither sweeten the walls of the sinus, nor affect the source of the trouble in the spine. It is astonishing how long some patients discharge without becoming the subjects of lardaceous disease, and how quickly others succumb to it. The explanation of this difference is in the thoroughness of the hygienic measures adopted. The author had a case of double psoas abscess in a child under his observation which had been discharging for ten years, yet the boy's urine is quite free from albumen, the spleen is not enlarged, and he is plump. He has been during this time at Broadstairs. At one time five sinuses were discharging. All have now healed, and the boy is strong and well.

Treatment of Sinuses by Vaccination.—The identity of the organisms should be determined. If the infection is mixed, being either B. coli, or streptococcus p. aureus or albus, or staphylococci, in addition to tubercle bacilli, then it is found to be advantageous to vaccinate for the septic organisms in the first place, and to increase the patient's resistance in this direction. Subsequent injections of tuberculin have then a greater effect.

Wright[1] has pointed out that a free flow of lymph into the sinus-

[1] *Practitioner*, vol. lxxx., May 1905, p. 603.

channel, with relief of the neighbouring engorged areas, is a great aid to healing, and he advocates citrated hypertonic salt solution for the purpose. It is made of two to four parts of common salt and one part of citrate of soda, dissolved in 100 parts of boiling water. "Sinuses may with advantage be syringed out with this lotion, a piece of lint soaked in the lotion being afterwards introduced into their orifices." A marked lymphagogue effect is produced.

Treatment of Sinuses by Paraffin Injections.—We have described this method on pp. 24-27, and given the details of its application. Suffice it to remark in this place, that we believe from our limited experience the method to be one well worthy of thorough trial, and very hopeful in its results, if care is taken in the selection of cures.

To sum up the treatment of spinal abscess.

1. Receding abscesses and quiescent foci are best treated on the expectant plan, with recumbency in the open air at the seaside.

2. Aspiration is useful if combined with injection of thymol-camphor injection, when the abscess is deeply seated and is slow in coming to surface, or if it is near the surface and the skin is not involved.

3. Cervical abscesses should be opened through the pharynx when dyspnœa and dysphagia are urgent, but otherwise at the side of the neck.

4. If psoas and lumbar abscesses are opened, the incisions must be multiple, and an attempt made to secure primary union after free evacuation of the contents and cleaning of the sac wall. Posterior mediastinal collections are best dealt with by costo-transversectomy.

5. Openings in or near the groin are not permissible in children, and drainage tubes are sources of trouble both from the danger of septic infection and the risk of converting the track of the tube into an infected sinus.

6. The possibility of removing large sequestra of bone, by cutting down on the vertebral column, is very problematical; and in a large number of cases no such proceeding is called for, the diseased bone being simply carious or caseous on its surface.

7. Dissecting out the sac is not often possible, but may be attempted when feasible.

8. Spontaneous opening of the abscess has often been followed by disaster.

9. Infected sinuses are sometimes amenable to vaccination, or to the paraffin injection method.

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By the courtesy and kindness of my friend Mr. Harold Stiles, I have had an opportunity of perusing the advance proofs of his writings on "Operations for Tuberculous Osteomyelitis of the Spine," which he has contributed to vol. ii. of Burghard's *Operative Surgery.* In operating for cervical abscess careful dissection down to the abscess sac by the lateral method is advocated, the sac wall is cleaned by repeated packing with strips of fresh gauze, and before closing the wound some sublimated iodoform bismuth paste (see p. 24 for its composition) is introduced into the cavity and rubbed into the lining with the finger. The wound may either be closed completely, or if the cavity be large and the pus less cheesy, an iodoform gauze drain may be left in for a few days. Referring to prevertebral thoracic abscess, Mr. Stiles remarks that "this condition is often revealed by skiagraphy when there are no symptoms indicating its presence." As we know, it frequently becomes absorbed under suitable general and local conditions. If not, Mr. Stiles approves of Heidenhain's method of posterior mediastinotomy, brought into prominence by Ménard under the name of costo-transversectomy (*q.v.* p. 185), the results of which are eminently satisfactory. Mr. Stiles goes very fully into the operative treatment of lumbar and iliac abscess, and shows how the operations should be planned, and that careful attention to anatomical details is essential to successful evacuation of the pus. He appears to us to favour immediate closure of the wound, even at the risk of its re-opening.

The Treatment of Compression Paraplegia

Of all organic nerve-lesions this form is the most amenable to treatment and by the simplest means. The methods are the following:—

By Absolute Rest in the Horizontal Position, combined with moderate hyper-extension of the spine, and if necessary with weight-extension to the head and lower extremities, excellent results are obtained. This course we adopt until the motor functions begin to re-appear, and then we place the patient in a semi-upright position on a spinal couch adapted for that purpose, or on Fisher's bed-frame (Fig. 66). It is curious to observe that some few patients cannot bear this position, and the signs of intolerance are occasional rises of temperature, some retraction of the head, and in all cases increase of the spasticity of the limbs, and greater activity of the deep reflexes, especially of the ankle. Under this form of treatment the percentage of recovery varies from 83 to 95 per cent—a truly remarkable result. As to the duration of treatment, recovery takes place in from three to eighteen months, and hope should not be abandoned under two years. Some patients have recovered from paraplegia in this way who have had two and three previous attacks. The cases which are most refractory are where there is incontinence of urine and fæces; and in these instances when recovery begins, the patient regains control over the bladder and rectum before voluntary muscular movements are restored. In fact, the order of recovery is rectal, visceral, sensory, and lastly, motor functions. It therefore follows that in all cases of paraplegia simple measures should be tried first and for a lengthened period.

If they fail, then we have to consider the forms of operative interference, and they are forcible redressment, laminectomy, and costo-transversectomy.

Redressment.—Mr. Robert Jones and the author had twelve cases of relief from paraplegia in ninety-nine cases of spinal disease so operated upon. It is to be noted, however, that redressment sometimes makes the patient worse, although as a rule the subsequent paralytic troubles are fugitive. It certainly does relieve some cases, because by augmenting the size of the destruction-area it diminishes the pressure on the spinal cord. And it undoubtedly relieves those rare cases of paralysis due either to a sharp edge of bone or to compression by a fragment. Nevertheless, it must be remembered that the proceeding is not free from risk. Before attempting it, an X-ray photograph should always be taken to determine the existence of abscess. In at least 50 per cent of cases of tuberculous caries, pus forms, and is either intra- or extra-spinal. The patient runs serious risk if an abscess is ruptured. Redressment, therefore, can only be recommended as a last resource.

Laminectomy.—It is not necessary to describe here the steps of this operation. It is based upon the theory that among the chief causes of compression are pachymeningitis and tuberculous granulation. It is in just these conditions that laminectomy has failed to give relief, and during the operation the cord may be infected by tuberculous matter.[1] Where laminectomy has afforded relief, it has been due to the accidental evacuation of a spinal abscess. The statistics of the operation are not by any means encouraging, and in some of the cases which are given as cured, it is not clearly stated that sufficient trial had been given to treatment by recumbency and extension. In some instances, to our personal knowledge, no trial at all had been made before operation was resorted to. The immediate mortality of the operation is large. Rhein[2] found that the death-rate of those dying within a month of the operation was 36 per cent, and Lloyd[3] in 128 cases noted that 21 (16·45 per cent) died from the operation itself; 36 (28·11 per cent) died subsequently; the total deaths were 57, or 44·55 per cent; recoveries were 37 (28 per cent); improvement took place in 16 (12·5 per cent); no improvement in 18 (14·06 per cent). Adding together the deaths and cases not improved, 75 (58·61 per cent) contrast with 53 (40·5 per cent) recoveries and improvements. Laminectomy is a grave operation in itself on account of the profound shock it causes; its success is feeble and often only accidental. It leaves the spine weaker than before, and the patient is therefore open to relapses which are often of a lasting nature and incurable. The operation should be reserved for those cases where every other measure has been tried and failed, and the patient is likely to die of bed-sores, bronchitis, or urinary troubles.

[1] Jackson Clarke, *Practitioner*, Sept. 1903.
[2] Willard, *Journ. Nervous and Mental Diseases*, May 1897.
[3] *Philad. Med. Ann.*, Feb. 22, 1902.

Costo-transversectomy.—The details of the operation as practised by Ménard have been outlined on p. 178, but a few words of description may be said. It remains to be said that, for the relief of compression, Ménard makes his incision horizontally, and preferably on the left side, over that rib and transverse process corresponding to the summit of the boss. He clears the periosteum off the rib, and cuts it away gradually from the angle inwards so as not to wound the pleura. He then divides the transverse process and removes it, and the finger is now insinuated along the spine until pus is reached, or a very blunt probe may be passed with care into the diseased area, when pus, if present, will escape. A drainage tube is then put in. It is worthy of remark that the finger, when placed in the inter-segmentary space, feels the effect of the respiratory movements on the segments, and this led Ménard to think of the rhythm of respiratory action as a cause of compressive ulceration in dorsal caries.

Costo-transversectomy is also useful in those rare cases of Pott's disease where there is pressure on the nerve-roots at their exit from the spine, and in those still rarer cases where there is hemiplegia from lateral pressure on the cord.

For costo-transversectomy its originator claims the following results. No deaths as compared with 30 per cent of Chipault's collected 103 laminectomies, or 44 per cent of 128 cases which Lloyd gathered together. Ménard up to the year 1900 had operated on 23 patients. In 12 cases there was immediate improvement commencing the same day, in 4 the improvement was seen in a week, and in 2 in three months. In 5 cases the result was tardy or *nil*. In 2 of the cases the failure was ascertained to be due to bony compression, and in the remaining 3 Ménard was unable to state if the cause were bony compression or secondary cord degeneration.

Costo-transversectomy is indicated, then, in all cases where the recumbent method has been tried and no improvement has followed, and in cases of rapid and acute paralysis with marked ascending and descending degenerative symptoms.

It should always precede laminectomy, and is safer than redressment. Ménard, by the by, instances one case in which the laminectomy had been tried without success, and relief was obtained by costo-transversectomy.[1]

[1] For references on this subject the following may be consulted: Ménard, *op. cit. sup.* p. 409 *et seq.*; Bradford and Lovett, *op. cit. sup.* p. 81; Royal Whitman, *Orth.*

Occipito-Atloid and Atlo-Axoid Disease

(*Spondyl-arthritis Tuberculosa*)

The joints of the first two vertebræ are usually affected by tubercle and syphilis, but more often by the former disease. Hence the terms "malum vertebrale suboccipitale" and "spondyl-arthritis tuberculosa."

In 46 per cent of the tuberculous cases, Lannelongue found that the disease commenced between the fifteenth and twenty-fifth years. It is generally seen in the early adult and mature years, but is not unknown in childhood. Inflammatory softening about the two upper cervical vertebræ is especially dangerous owing to the possibility of sudden death from displacement backwards of the odontoid process and compression of the medulla.[1] Occasionally cases are examined where the displacement is seen to have been gradual.

Pathology.—The disease begins either in one of the synovial membranes or in the bones—in about equal proportion. The changes in the synovial form are those usually seen in tuberculous joints, and the cartilages are worn away until bone meets bone. Purulent distension and perforation of the capsule take place, and a peri-articular abscess is formed. The osteal or subchondral form gives rise to similar changes in the joints. The base of the odontoid process is a common spot for the disease to begin at, and then the transverse ligament becomes softened. Other spots of predilection in the bone are the lateral insertions of the transverse ligament. Occasionally the synovial form is arrested at the stage of mere adhesions with limitation of movement.

Course of the Disease.—In both forms the atlo-axoid joints are more frequently involved, and disease spreads to the neighbouring parts. This course of development is said by Wullstein[2] to be very characteristic of tuberculous spondyl-arthritis. The atlas may

Surg. 3rd ed. p. 122; Hubbard, *Trans. Amer. Orth. Assoc.* vol. ix. p. 150; Tillmann, Langenbeck's *Archiv*, vol. 69, Nos. 1 and 2; Lüning and Schultess, *op. cit. sup.* p. 374; Kraske, *Archiv f. klin. Chir.* vol. lxi.; Jackson Clarke, *Practitioner*, Sept. 1903; Chipault, *Le Traitement de mal de Pott*, p. 99; Max David, *Grundriss der orth. Chir.* p. 78; Wicking, *Archiv f. klin. Chir.* Bd. 71, p. 479, 1903; also *Deutsche Zeitschr. f. Chir.* Bd. 70, p. 112; Goldthwait, *Trans. Amer. Orth. Assoc.* vol. xii., 1899, and many others of earlier date, mentioned in the first edition of *Deformities*, pp. 71 and 72.

[1] *Cf.* the classical case quoted by Hilton, *Rest and Pain*, 3rd ed. pp. 109-112.

[2] Wullstein, Joachimsthal's *Chir. Orth.* Pt. I. p. 1375.

be more or less completely destroyed and absorbed, so that the occiput rests on the axis; and, ankylosis taking place, recovery follows, with a marked shortening of the neck. The process of erosion is not, however, equal, especially at the beginning, but is greater at some typical spots, which are generally found in the anterior arch of the atlas and about the odontoid process. So that the head glides forward on an inclined plane. Thus is produced the typical forward position of the head. So marked may this become that the chin rests on the sternum. As the posterior border of the foramen magnum approximates to the base of the odontoid process,[1] the medulla is in danger of becoming compressed. Yet, actual dislocation apart from trauma is rare, on account of the rigidity and stiffening of the parts due to the marked infiltration of the posterior ligaments and the muscles.

Even when subluxation takes place in the atlo-axoid joint the cord may not be injured, because it sometimes happens that there is a tilting sideways (*cf.* Malgaigne's case); or the odontoid process being separated at its base, may be ankylosed to the atlas and carried forward with it, and so the marrow escapes.

Fatal compression of the medulla occurs when the transverse ligament gives way suddenly; and gradual compression arises from the same causes as in compression paraplegia from disease elsewhere in the spine.

Symptoms.—Neuralgic pain in the great and small occipital and the great auricular nerves is felt at the onset of the trouble. The pain soon becomes of an acute lancinating nature in the mid-line of the neck, radiating over the back of the head and toward the mastoid process. It is also felt in the parotid region and in the terminal filaments of the great auricular nerve. Interference with the movements of the tongue and loss of co-ordination in swallowing arise from irritation and pressure on the hypoglossal nerve. Vulpius and Oppenheim have observed atrophic paralysis of one-half of the tongue in three cases. The pupils are unequal, and occasionally spasm of the eyelids and nystagmus, due to œdema or pressure of exudation on the floor of the fourth ventricle, are met with.

Pain is momentarily intensified by pressure on the posterior part of the arch of axis; and it ceases when an abscess, pre- or post-vertebral, comes to the surface, bursts, or is incised. After

[1] The odontoid process may be quite destroyed or separated as a sequestrum.—Jackson Clarke.

the advent of pain, the patient is seen to hold the head in a peculiar, rigid, and fixed position (Fig. 100); and if the muscles are inefficient in their control of the weight of the head, the patient supports it by the hands.

Occasionally the head, instead of being flexed anteriorly, is deviated laterally. This is symptomatic of unilateral disease, affecting the side toward which the head is turned. Von Bergmann has remarked that, if the disease has extended into the soft tissues superficial to the bones, the patient, in order to relieve the muscles of the sulcus paraspinosus on the affected side, turns the chin towards the side on which the disease originated. This is a valuable point of differential diagnosis, and serves to distinguish this disease from torticollis of congenital origin, where the head is deviated to the same side, and the chin to the opposite side, on which the contracted muscles lie. We may also note that in occipito-atloid disease the patient, in place of turning the head, twists the trunk.

FIG. 100.—Cervical Tuberculous Spondylitis. Observe the position assumed by the head in this form of disease, and the fulness of the neck posteriorly (Holmes' *System of Surgery*).

Later, a hard swelling forms beneath the occiput, and spreads laterally to the mastoid processes. Fluctuation may be felt in any part of the swelling. The formation of retro-pharyngeal abscess is not uncommon, so that the voice becomes nasal, breathing through the nose is diminished, and there is mechanical difficulty in swallowing. A retro-pharyngeal abscess, due to disease of the first two cervical vertebræ, does not spread downwards, but remains localised behind the naso-pharynx (Wullstein).

The head may simply sink down, and the neck shorten, if the bone erodes equally in a horizontal plane; or it may tilt sideways if a unilateral erosion be present. Nevertheless, the characteristic position is flexion of the head and neck, and sliding of the head downward and forward.

As the head assumes new positions, nerve-symptoms appear. The arms are first affected, motor paralysis, paræsthesiæ, and dysæsthesiæ, and later, anæsthesia appear, and are followed by paralysis of the bladder, rectum, and legs. Then the diaphragm becomes involved, and death takes place from asphyxia. It is found that the motor paralysis always comes on earlier, and is more marked than sensory.

Sudden total paraplegia has been caused either by manipulation or by incautious movements of the patient.

It is possible to differentiate disease of the atlas and occipito-atloid joints from that of the axis. In the former, nodding or flexion and extension movements are lost early; in atlo-axoid disease rotation is the first to go. The movements of the other cervical vertebræ are naturally free, and therefore care is requisite if we desire to avoid overlooking early trouble in the upper two segments.

Diagnosis.—The symptoms are characteristic, but mistakes have been made, or the affection has been confused with fixed torticollis, sarcoma of the base of the skull, or fracture-dislocation.

In torticollis the head is deviated to the affected side, and the chin to the opposite side. It is not necessary to recapitulate the remaining points of distinction. Sarcoma of the base of the skull, both v. Bergmann and Bidder point out, has been a cause of mistaken diagnosis; Bergmann has remarked that extension of the neck intensifies pain in sarcoma. Fracture or dislocation is distinguished by its history; and both here and in sarcoma an X-ray photograph will be of the greatest service.

Prognosis.—Spondyl-arthritis tuberculosa presents more unfavourable features than any other form of spinal disease, especially if there are evidences of progressive involvement of the medulla and cord. The usual duration is one to two years. Teissier, however, records a case in which the whole course occupied twelve weeks. Sudden death occurred in cases quoted by Hilton, Sédillot, Lannelongue, and Tillaux. Buckley narrates the following interesting case:—"A child of seven years of age, without any suspicion of disease, choked in swallowing. Another child slapped it on the back to help it, and it fell forward dead. At the post-mortem examination the base of the odontoid process was found eaten through by caries, and the other bones and joints of the spine were normal."

Quite exceptionally, the disease runs a short course and heals. Teissier has collected twenty-six cases which have recovered. Patients also have survived in whom the atlas has been almost totally destroyed, and the occiput ankylosed to the axis. It is probable that vaccines, therefore, will improve the prognosis of these dangerous cases.

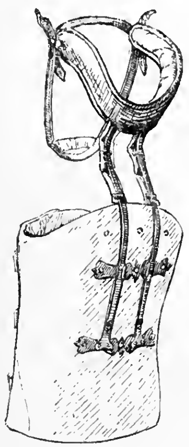

FIG. 101.—Poroplastic Jacket with Occipital Headpiece and Chin-support for Cervical Caries. In place of the sling for the chin, a metal chin-lever may be used.

Treatment.—The same principles apply here as to the treatment of acute tuberculous disease of the spine elsewhere; horizontal recumbency should be absolute, and no movement whatever of the head permitted, until all the acute signs have subsided. Afterwards, the upright position is gradually assumed, and every precaution is taken to fix the head, neck, and shoulders. In order to steady the head efficiently, the trunk must be encircled with a support, on which is a superstructure for holding firmly the head and neck (see Fig. 101). At a later stage, a leather collar (Fig. 102) is very useful. Neuralgic pains are felt after the disease has healed, and cause the patient much anxiety, and the surgeon considerable searching of heart.

Vaccination with tuberculin may be tried. Abscesses are dealt with as they arise; and in opening them, the head should on no account be moved incautiously.

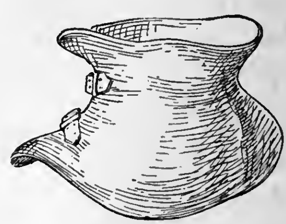

FIG. 102.—A Leather Collar used in the after-treatment of cervical caries and of wry-neck.

Pott's Disease in Infancy.—At this age tuberculous caries is comparatively more common at the dorso-lumbar junction, and in the lumbar vertebræ, than later in life. The difficulties of diagnosis are increased by two facts—the one being that as the infant is incapable of walking, we are deprived of the information to be gained from the standing or sitting positions, and from the contour of the spine; and the other is that so many infants are the subject of kyphosis from rickets. Owing to these points, difficulties in diagnosis may occur. It is also far from easy in some instances to tell if it is the lumbar spine or the hip-joints which are involved. In Pott's disease in infancy the muscular spasm is intense, and its extent is great. The child screams when it is moved and when the diapers are changed (Whitman), and dressing the child is accompanied by cries indicative of excessive pain.

The best test is to let the infant lie on its face and note the flexibility of the lumbar spine on raising the legs from the couch. In rickets all the kyphosis will disappear, and be replaced by lordosis when the legs and pelvis are lifted, and the movement will be more free than normal and painless. In tuberculous disease the degree to which the legs and pelvis can be raised is much restricted, the kyphosis or the straightness of the spine is not replaced by lordosis, and pain is caused during the manœuvre.

Spondylolisthesis

Definition.—In English works spondylolisthesis is synonymous with chronic dislocation at the lumbo-sacral junction.

Spiegelberg states that since the time of Kilian spondylolisthesis has meant the detachment of the last lumbar vertebra from the sacrum, and the consequent gliding forward of the lumbar vertebral column owing to the weight of the trunk.[1]

Occurrence and Frequency.—Whilst the majority of cases affect the lumbo-sacral junction, yet it is not always so. Lovett analysed 43 cases, and found the fifth lumbar subluxated forwards in 30 cases, the fourth in 12, and the first sacral in 1.

It is also important to recognise that as a rule the centrum only is displaced, the arch remaining *in situ*. This implies either a solution of continuity or elongation of the pedicles.[2]

Description.—The extent of the displacement varies from a slight luxation (Fig. 103) to a dislocation so complete that the fifth lumbar vertebral body is rotated forward and downward through 90°, and its normally inferior surface becomes apposed to the front of first or first and second pieces of the sacrum (Fig. 104); and eventually more or less synostosis results with the bones in this position. The normal anterior surface of the fifth lumbar

[1] Acute traumatic cases, that is, fracture of the articular processes with immediate dislocation at the lumbo-sacral junction, are simply described as such.

[2] The laminæ do not always remain in place. Thus Arbuthnot Lane performed a laminectomy to relieve pressure by them on the lumbo-sacral cord.

looks now downwards, and the fourth forms an angle with the fifth somewhat like the normal sacro-lumbar angle. The true pelvis is thus roofed in more or less and blocked.[1]

The pedicles of the displaced vertebra are found to be either

Fig. 103.—Small Pelvis of Prague (median sagittal section), showing slight forward displacement of the fifth lumbar vertebra (Neugebauer).

Fig. 104.—Pelvis of Moscow (median sagittal section), showing extreme forward displacement of the fifth lumbar vertebra (Neugebauer).

thinned and elongated, but intact, or actually severed; whilst the laminæ and spinous processes, though retaining more of their normal relations, may be forced somewhat backwards, or more rarely be depressed (Fig. 105).

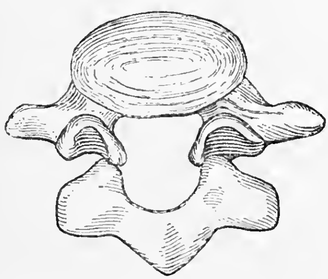

Fig. 105.—Illustration of a specimen, from Kölliker's Museum at Wurzburg, showing separation of the posterior part of the vertebral segment (Neugebauer).

As the results of pressure- and functional changes, the affected body may become wedge-shaped, its lower intervertebral disk disappear, and synostosis with the sacrum result. The first piece of the sacrum often becomes lipped and drawn forwards. The disks and vertebræ above the lesion are fan-shaped, and adapt themselves to the increased lordosis necessary at this part. The point nearest the symphysis pubis is now not the sacral promontory, but the lower margin of the 4th, 3rd, or even 2nd lumbar.

[1] In effect, obstetrically, spondylolisthesis is much the same as spondylolizema (Hergott), in which the pelvis is roofed in by a marked kyphosis at the sacro-lumbar junction, or else quite low down in the lumbar region.

Neugebauer describes the following types :—

A. Neural arches separated from bodies.

i. Defect of development. Congenital form.[1]

ii. Traumatic form from fracture.

B. Elongation or subluxation of the vertebral body forwards from

i. Disease.

ii. Due to superimposed weight and pressure changes.

Though it is true that failure of osseous union between the centrum and arches is far from uncommon, yet since marked spondylolisthesis is very rare, it is clear that other factors are con-

FIG. 106.—Spondylolisthesis, due to disease at the Lumbo-sacral Junction (Bradford and Lovett, after H. H. Cushing, Johns Hopkins Hospital).

cerned. Such may be injury, excessive weight carrying, or multiple pregnancies.

The traumatic form is well authenticated, and only cases coming on gradually a considerable time after injury are as a rule included in spondylolisthesis.

Disease of the sacro-vertebral articulation (Fig. 106), whether arising from injury or tubercle, or any other form of arthritic inflammation, and resulting in softening of the retaining ligaments, is accepted by all writers as an actual cause.[2]

Possibly the association of spondylolisthesis and pregnancy may

[1] Named spondylolysis or spondyloschisis.—Lambl.

[2] Also tabes dorsalis. Krönig, *Zeitschr. f. klin. Med.*, 1884 and 1888.

be due to the several factors of softening of the pelvic articulations, the strain of increased weight-bearing, and the mechanical effect of the increased lordosis at the lumbo-sacral junction.

Lastly, Arbuthnot Lane holds that hard work and pressure, due to carrying weights, may be sufficient alone to cause elongation of the pedicles and final absorption, with division of the laminæ. Lane holds that the condition is not uncommon amongst the classes subjected to heavy labour. In fact, he regards spondylolisthesis as almost a normal condition in such workers as coal-heavers.

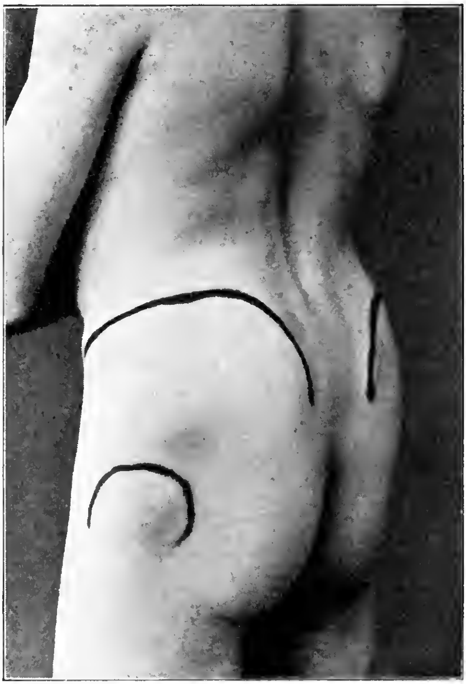

Fig. 107.—A view of the Postero-lateral Aspect of a patient, with Spondylolisthesis. Observe the flattening and elongation of the gluteal region on either side. The dark lines indicate the crests of the ilia and the great trochanter. From a patient, under the author's care at Westminster Hospital.

Causation.—It is at present very difficult to be dogmatic. Most of the well-marked museum specimens are deficient in history, but there seems little doubt that an injury, such as a fall downstairs, is very often the starting-point of the affection. The female sex, even apart from pregnancy, are more vulnerable in this respect than males, and frequent pregnancies undoubtedly have an adverse effect. It seems as though, on the one hand, the ligamentous relaxation consequent upon repeated pregnancies predisposes to the onset of spondylolisthesis after slight injury; while, on the other, spondylolisthesis, if already begun, becomes rapidly worse when pregnancy supervenes.

What is wanted is a more accurate knowledge of the state of the pedicles and articular processes in early cases; but such information is difficult to get, because, in the first place, early cases are seldom recognised at all, and in any case are rarities. And in the next place, the danger to life occurs in advanced cases only when

Cæsarean section is performed because of insuperable difficulties in parturition.

Symptoms.—On looking at the illustration of the specimens given on p. 192, it will be seen that the spinal column is shifted considerably downwards and forwards from its normal position. A corresponding displacement, of course, of the whole trunk above the pelvis takes place—that is to say, the line of gravity is displaced forwards. To compensate this, that is, to restore the equilibrium, the pelvic inclination is diminished. The symphysis pubis is on a level with the first piece of the sacrum, and it may even be higher than this.

The direct deforming effects of these two changes, *i.e.* diminished pelvic inclination with forward and downward displacement of the vertebral column, are, that the whole trunk appears and is shortened, the shortening being evidently in the abdominal region, the thoracic being normal. The shortening effect is much intensified if viewed from the front, owing to the high position of the symphysis. The diminished inclination of the pelvis causes the gluteal region to appear very broad and flat, and the posterior inferior iliac spines are unduly evident. Above the sacral region and prominent iliac crests the lumbar region and loins fall away, giving a peculiar "saddle-back" appearance. The buttocks are small and ill-developed, and the posterior pelvic outline is quadrilateral and looks generally pushed upward (Figs. 107, 108, 109).

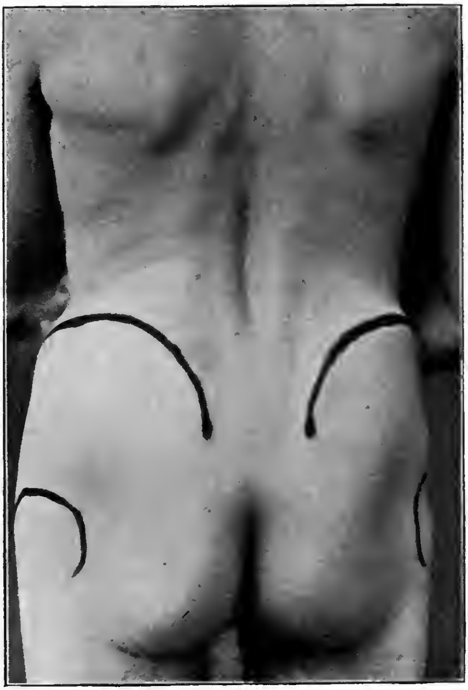

FIG. 108.—A posterior view of the same patient as in the preceding figure. The buttocks are small, flattened, and as it were dropped, and the distances from the angles of the scapulæ to the crests of the ilia are lessened.

The lumbar lordosis, diminished pelvic inclination, and shortening of the trunk give a very characteristic, indeed, according to Neugebauer, a pathognomonic appearance, and the diagnosis is confirmed by vaginal, or better still, by rectal examination.[1] The finger passed up along the front of the sacrum comes to an angle formed by the prominent vertebra, whilst, laterally to this, the normal contour of the sacral alæ can be traced.

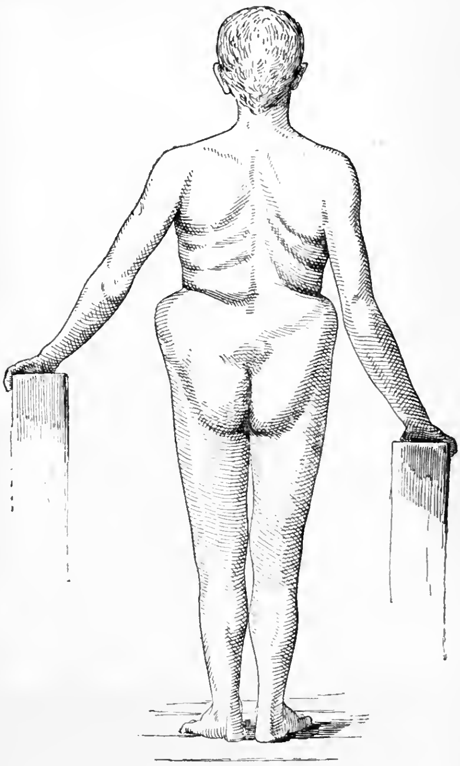

FIG. 109.—A posterior view of a case of Spondylolisthesis, in a woman aged 30 years (Breesky).

Secondary to the pelvic displacement, the hips, knees, and ankles are somewhat flexed, according to the mechanism described elsewhere. Lovett suggests that the flexion of the hip may be explained by the tension of the anterior ligaments of the joints.

If the spondylolisthetic vertebra be the fourth or third lumbar, then examination under an anæsthetic and palpation through the abdominal wall will reveal a striking state of affairs. Instead of there being an appreciable distance between the spine and the anterior abdominal wall, the surgeon's hand comes down at once on the displaced vertebræ as if they were actually in contact with the parietes. I have found this method of confirming the diagnosis useful in two cases. Skiagraphy is of some value.

Diagnosis.—Whilst the appearance of the patient, especially of the posterior aspect, is suggestive of congenital dislocation of the hips, yet we must remember that in the latter affection it is the legs and not the trunk which are shortened, and the gluteal region is not flattened, but the reverse. Then the trochanters are above

[1] Possibly the bifurcation of the aorta may be palpable.

Nélaton's line, and the heads of the femora are out of place, and can in most instances be telescoped.

From Pott's disease of the lumbar spine the diagnosis is more difficult. Here, however, flattening of the lumbar spine is the rule, and later on prominence of the spinous processes, whereas in spondylolisthesis lordosis is present, and the line of the spinous process curves forwards. Then, in Pott's disease there are other substantive signs, such as muscular and bony rigidity of the affected region. In rickets the pelvic angle is increased, and lordosis is the exception, not the rule.

Finally, in spondylolisthesis we must rely upon these signs, a history of injury or of pregnancy succeeded by lumbar lordosis, and diminished pelvic inclination, disturbance of equilibrium in walking, shortening of the trunk, and flexion at the hip-joint.

Treatment.—Prolonged rest in bed with weight-extension to the legs, and counter-extension by raising the end of the bed, is likely to be of more service than most other forms of treatment, especially if recumbency be followed by a steel spinal support, a poroplastic or a plaster of Paris jacket, carried well downwards on the hips. In one case W. Arbuthnot Lane was obliged to perform laminectomy for paralytic symptoms due to pressure (p. 191). The gravest difficulties arise in parturition, which is often followed by fatal results.[1]

References to Spondylolisthesis

Fr. Neugebauer, of Warsaw, has thoroughly investigated and elaborated the subject. His *Spondylolisthesis et spondylizème*, Paris, G. Steinheil, 1892, is a critical review, with description of specimens and cases, and complete bibliography. Also compare—

Chiari. Zeitschr. f. Heilk., 1892.

Bohn. Inaug. Diss., Berlin, 1892.

Lane. Lancet, 1893, xxix. p. 991.

Lane. Guy's Hosp. Rep. xliii.

Lane. Lancet, April 1892, No. 358.

Lane. Path. Trans. vol. xxxvi.

Hertzfeld. Allg. med. Zeitschr., 1892, xxxvii.

Braun von Fernwald. Arch. f. Gyn., 1896, lii. p. 8. (The most carefully recorded and illustrated of any case.)

[1] Galabin, *Midwifery*, gives Swedelin's statistics, which show that the outlook, obstetrically, is serious if the case is at all marked. "Of the 19 mothers, 8 died or 42 per cent, 1 after abortion, only 3 after Cæsarean section. Of the children, 16 passed the genital canal alive, 4 being delivered by Cæsarean section." He is dealing with 48 pregnancies in 19 spondylolisthetic women.

JELLINGHAUS. Arch. f. Gyn., 1896, p. 428.
BILLROTH. Arch. f. klin. Chir., 1896, Band x. p. 42.
KILIAN. Die Spondylolisthesis, Bonn, 1853.
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BARNES. Trans. Obstet. Soc. vi. p. 78.
NAPIER, C. D. Amer. Journ. Orthop. Surg., Oct. 1905.
SPIEGELBERG. Text-book of Midwifery.
GALABIN. Manual of Midwifery.
BENNETT. Lancet, July 20, 1889.
TARGETT. Obstet. Trans., 1891.
ROTH. Chir. Soc., London, 1891.
LOVETT. Trans. Am. Orth. Assoc. vol. x.
SWEDELIN. Arch. für Gynäk. Band xxii. Heft 2.

Ankylosing Tuberculous Rheumatism Affecting the Spine

Under this title French authors describe a condition where the spine slowly becomes stiff and fixed throughout its length. Gradually it bends and a marked kyphosis appears, sometimes with and sometimes without lateral deviation, and accompanied by considerable pain and discomfort. It is seen in phthisical subjects, and so far as observations go, it does not present the clinical characteristics of ordinary tuberculous spondylitis. The curve is distributed throughout the spine, exactly as in spondylitis deformans, and no marked angular deformity appears. There is no breaking down into caseous material, with the appearance of abscess, and paraplegic symptoms are not mentioned in the accounts of the cases. The occurrence of polyarthritis is mentioned, however, by writers.

The title given to the affection is a cumbrous one, implying that rheumatic pains precede and accompany the deformity, that it occurs in tuberculous and usually phthisical subjects, and that ankylosis more or less universal sets in. So far no pathological specimens have been exhibited, yet it may be a form of superficial caries of the bodies accompanied by inflammatory and osteophytic changes in the intervertebral articulations.

Articles have appeared in the *Revue d'orthopédie,* one by Leriche in May 1905 entitled "Chronic Deforming Tuberculous Rheumatism," and a second by P. Gauthier in July 1905 entitled "Ankylosing Tuberculous Rheumatism."

Leriche quotes the case of a man aged thirty-two years, who in infancy was affected with enlarged cervical glands, and during the first year of his military service had a painless swelling of the metacarpo-phalangeal joints, and the movements were progressively diminished. The fingers were flexed at right angles and deviated to the ulnar side. Eight months before the date of report he had two "cold" abscesses of the thoracic wall, and four months previously he had double tuberculous epididymitis and general "indolent" adenopathy. The pus from the abscess in the thoracic wall when injected into a guinea-pig gave positive evidence of the presence of tubercle bacilli. Leriche also refers to another case of chronic deforming polyarthritis of both hands, with an enormous abscess associated with chronic arthritis of the left knee, and "cold" suppurative osteitis of the radius, femur, and tibia. Skiagrams of the hands showed thickening of the shafts of the phalanges. In this connection the conclusions of Mousy [1] and Merson are interesting; they found in sanatoria one "rheumatic" case "in five patients affected with phthisis."

P. Gauthier refers to a marked example of spondylitis rhizomélique caused by ankylosing tuberculous rheumatism, and alludes to several examples in the recent theses of Levet, Moutet, and Gerspacher. Gauthier quotes the following case:—A blacksmith aged forty-nine years, in 1873 had acute gonorrhœal arthritis, in 1884-85 tuberculous cystitis, and in 1890 bronchitis, wasting, and blood-stained sputum. Latterly he has had headache and deafness due to "dry" otitis. At the present time he has phthisis pulmonalis, and complete ankylosis of the whole spine, which moves *en bloc*. The vertebral and costo-vertebral articulations are so fixed as to make an immovable framework, and he cannot even nod his head. He also has dry arthritis of both shoulders, hips, and knees, which are stiff and crackling. In Gauthier's opinion the condition is one of ankylosing polyarthritis becoming general. It is tuberculous in origin, and has therefore the same ætiology as mon-arthritic tuberculosis.

I have also had two anomalous cases under my care in sanatorium patients, in whom rheumatic pains in the spine were succeeded by rigidity of the whole column, general antero-posterior curvature, and some loss of mobility of the ribs in respiration. In one case the spinal symptoms were worse during each exacerbation of pulmonary tuberculosis, and improved in the intervals.

In Leriche's cases we have examples of a chronic polyarthritis

[1] Mousy, *Le Rhumatisme tuberculeuse au Sanatorium d'Hauteville*, Thèse, 1905. Merson, *Du rhumatisme tuberculeuse observée récemment dans les Sanatoria de Leysin*, Thèse de Lyon, 1903.

occurring in tuberculous cases without spinal affection. In Gauthier's case we find polyarthritis with spinal ankylosis, and in my cases the latter without polyarthritis. The subject requires most careful investigation. Are we warranted in assuming that the tubercle bacillus can generate a toxin which has an effect on bones and joints comparable to that produced by the gonococcus, and possibly with that which may act in arthritis deformans? Or are these cases of so-called "Ankylosing Tuberculous Rheumatism affecting the Spine," nothing else than a kind of discrete infection of the whole spinal column? The latter hypothesis seems the more probable, and it is strengthened by the fact that one of my cases ultimately developed a definite tuberculous focus in the lumbar region, with loss of the normal lumbar curve, and extreme flattening.

CHAPTER V

TUBERCULOSIS OF THE SACRO-ILIAC JOINT

Ætiology—Pathological Anatomy—Symptoms and Duration—Diagnosis—Treatment.

Synonyms—French, *Sacro-coxalgie*; German, *Sacro-coxalgia.*

THE sacro-iliac joint, like other articulations, is subject to inflammation due to traumatism, gonorrhœal, osteomyelitic, and pyæmic affections. It is also affected by rheumatism. Sacro-iliac disease is, however, usually chronic, and then it is almost invariably tuberculous. Happily it is of rare occurrence, and seldom met with except by those who are in the habit of seeing a large number of arthritic diseases. It is not necessary to dwell upon the acute aspect of sacro-iliac disease because of its rarity, and we shall here speak of the tuberculous form.

The chronic affection was first recognised by Boyer in 1814.[1] He described it as being of scrofulous origin, and recognised its analogy with white swelling of the other articulations. The names of Velpeau, Larrey, Langier, Erichsen,[2] Délens, L. A. Sayre, and in late years of W. van Hook,[3] are closely associated with the pathological and clinical description of the disorder.

Ætiology.—The affection is rare in infancy, childhood, and old age. The majority of cases occur from the fifteenth to the thirty-fifth years of age. Of 32 cases, in which the age was recorded, van Hook found 21 were affected between the ages of 15 and 35 years. The disease has, moreover, been seen in infants under 5 years of age and in adults of 45, 55, and 61 years. The explanation of its greater incidence during the most vigorous

[1] *Traité des maladies des os du bassin*, 1814.

[2] *Lancet*, 1859, ix. p. 25.

[3] *Ann. of Surgery*, vol. viii. p. 401; and vol. ix. pp. 35 and 115. In his articles a full historical account is given of the affection.

years of life is to be found in the greater exposure of the joint to traumatism. Certainly, it appears that injury is constantly an antecedent of the tuberculous form. Some of the victims of the disease were gunners accustomed to ride on jolting caissons and others were cavalry soldiers, whilst the children affected were chiefly those addicted to violent sports. In fact, some authorities, especially Sayre, believe that traumatism is an invariable element in the ætiology of tuberculous sacro-iliac disease.

Pathological Anatomy.—The normal sacro-iliac joint may be regarded as either a diarthrosis or an amphiarthrosis. It is peculiar, inasmuch as two large masses of spongy bone enclose a very small synovial cavity, and the bones are bound together by ligaments of great strength, especially the anterior and posterior sacro-iliac ligaments. In the structure of the bones, in the smallness of the synovial cavity, and the strength and density of the ligaments, it affords a close analogy to the vertebral articulations.

The affection is either right or left-sided, but is almost always unilateral. König has described one bilateral case. The disease has been described as beginning both in the synovial membrane and in the bone. No operative or *post-mortem* proof can be given, supporting the idea that a primary tuberculous synovitis occurs in this joint.

Either the auricular facet of the ilium, or very often the anterior aspect of the sacrum, is the part first affected. Lannelongue stated that the sacral lesion may be either primary or secondary, and due to extension of lumbar spinal caries. The anterior aspect of the sacrum is often stripped of its periosteum over a considerable area, and the lateral mass is sometimes deeply excavated and filled with tuberculous granulations; or, there may be an isolated sequestrum embedded in granulations; or, a necrosed mass of bone may be found lying free in the articular cavity. Sometimes, rarefying osteitis causes superficial ulceration in the joint; at other times, tuberculous foci are seen in the thickness of the sacrum, analogous in appearance to the caseous areas seen in the vertebræ in Pott's disease. The iliac bone is affected in a similar manner, but as a rule the changes here are not so far advanced.

Observers are agreed that the disease runs one of three courses. It may be what is commonly known as the dry form—caries sicca—in which no pus is formed. Or, it may be the moist form, and suppuration is an early feature; or, the dry form may at any time become suppurative.

With regard to the more minute changes in the joint, they are in no way dissimilar from those seen in the vertebral column. The lumbar glands are often enlarged, and sometimes caseous, and the peritoneum in the neighbourhood of the sacro-iliac symphysis becomes covered with tuberculous granulations, which may be the starting-point of tuberculous peritonitis. It frequently happens that the granulations surround the branches of the sacral nerves, especially the great sciatic at its point of issue from the pelvis. Occasionally the nerve trunks traverse an abscess cavity, and Lannelongue says "they show at least superficial signs of interstitial inflammation." According to Young,[1] in 55 collected cases, abscess occurred in 38; and, as we shall see presently, the occurrence of abscess is a grave element in prognosis, because it is liable to become contaminated, and to give rise to mixed infection.

When pus has formed in the joint, it may track either through the anterior ligament of the joint and become intra-pelvic and formidable, or force its way through the stronger posterior ligament and become extra-pelvic and less dangerous to life. An intra-pelvic abscess may pass upward to the lumbar region, or outward and forward beneath the ilio-psoas, and make its way down towards the thigh along the line of that muscle. It may also pass directly downward, and reach the superficial tissues through the sciatic notch, or appear in the ischio-rectal fossa and open into the rectum or perineum. An extra-pelvic abscess either passes directly backward and points over the joint, or appears in the lumbar region, or dissects downward into the gluteal region. Van Hook remarks that thus it will be seen that abscesses appearing immediately over the joint are invariably extra-pelvic, and those pointing in the gluteal region may be either extra or intra-pelvic, chiefly the latter. They may be distinguished by the fact that the tumefaction in extra-pelvic cases is continuous, though not necessarily uniform, from the joint to the centre of the abscess, whilst in the cases in which the abscess proceeds from the sciatic notch the external aspect of the joint presents no connection with the pus cavity. The origin of abscesses in the lumbar region is determined by tracing the pus pocket back to its point of origin. The abscesses arising in the sacro-iliac joint and pointing in the femoral region, in the rectum, perineum, or iliac fossa, are invariably of intra-pelvic origin. The proportion of intra-pelvic to extra-pelvic abscesses has been found to be 61·8 per cent to 38·2 per cent.

[1] *Orthopedic Surgery*, p. 297.

Symptoms and Duration.—The disease may commence either in a subacute or chronic fashion, precisely like other tuberculous diseases of joints. In most cases the onset is extremely insidious, and the symptoms are very vague. Erichsen, in his classical description, detailed five cardinal symptoms—pain, lameness, changes in the attitude and length of the limb, swelling, and abscess.

Pain.—This is usually the first symptom. It is situated over the sacro-iliac joint, and radiates towards the thigh and the knee, or upward into the lumbar region. It is usually neuralgic in character, and sometimes it resembles sciatica, except in one important point. In the latter affection the pain is found in the course of the sciatic nerve below its exit from the pelvis. In sacro-iliac disease the pain is of the sacro-lumbar type as well and spreads upward. Even before pain sets in, the patient experiences a sensation of weakness in the lower part of the back and sacrum, which is increased by walking, stooping, or standing, and the sensation is as if the body were falling asunder. As the disease progresses, not only are movements painful, but the sitting or standing posture soon becomes distressing, so that a simple change of attitude evokes a spasm; whilst during defæcation and rectal examination the neuralgic pain is intensified. Later, the patient becomes entirely unable to sit up, and even lying on the affected side is impossible. The pain is at first intermittent, then after a time becomes constant and severe, and when abscesses have formed the distress is aggravated. Erichsen has noted a sign which is almost pathognomonic. When the ilia are pressed towards one another, pain localised in the joint is felt. We insist again upon the radiating character of the pain, and the fact that it is not limited to one nerve trunk.

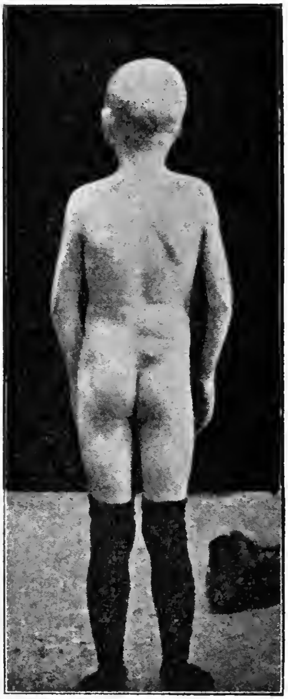


FIG. 110.—Right-sided Sacro-iliac disease (Ridlon and Jones).

Lameness.—At first it is noticed towards the close of a day's activity, and the patient takes small steps, fearing to throw any stress upon the parts. The attitude is characteristic (Figs. 110, 111, 112).

Fig. 111.—Sacro-iliac disease, left side, non-tuberculous (J. E. Goldthwait).

He tilts the pelvis on the affected side, so as to throw the greater part of the weight on the sound side. In order to maintain the balance, whilst the pelvis is tilted upwards on the affected side, the trunk is inclined also to this side, and a long C-curve in the spine, with its convexity towards the sound side, develops (Fig. 111). In standing, the heel on the affected side is usually placed on the ground, but nearly all the weight is borne upon the sound limb. Dragging of the affected leg is sometimes seen. Such are the usual changes in attitude and progression.

Fig. 112.—Tilting of the Pelvis in Sacro-iliac disease.

The gluteal muscles on the affected side become atrophied, and the buttock is flat.

Changes in Length.—These are apparent only and not real. It was formerly supposed that such softening of the ligaments took place that the ilium dropped away from the sacrum and real lengthening occurred. But we are now constrained to admit that the lengthening is apparent only, and is due to an altered position of the whole pelvis and the deviation and twisting of the lumbar column. It has also been noted that occasionally apparent shortening is present.

Swelling.—When present, it is a useful aid to diagnosis. Until suppuration occurs, the size of the swelling is not great, and it is more or less circular in outline. Very frequently, even in early stages, by rectal examination a thickening can be felt over the anterior aspect of the joint; in no case should such an examination be omitted.

Abscess.—When pus forms the swelling increases and becomes œdematous. Later it fluctuates, and it alters in shape and may become elongated. As we have remarked, a minority of cases do not end in suppuration, and therefore fluctuation is absent throughout the disease. When the abscess is intra-pelvic, fluctuation will only be detected externally if the pus has made its way to the surface by one of the routes already described, although a fluid swelling can in this case always be felt *per rectum.*

Even in early stages of the disease the temperature of the parts over the joint is raised.

Diagnosis.—The first point in the case of disease of the sacro-iliac joint is to establish its identity. We have said that the joint is liable to various forms of suppurative inflammation, to gonorrhœal rheumatism, and acute articular rheumatism. The acutely suppurative lesions, often of osteomyelitic origin, are distinguished by the violence of the constitutional symptoms and by the early formation of pus. In acute rheumatism the joint is much more tender from the first than in tuberculosis, but the tenderness rapidly yields to appropriate treatment by salicylate of soda and other drugs. The recognition of other rare affections of the joints, such as syphilitic or those due to arthritis deformans, depends upon careful inquiry into the history and examination of the joints elsewhere.

There are three groups of affections with which sacro-iliac disease, especially in its early states, may be confounded. These are: (1) Neuralgic; (2) Muscular affections; (3) Diseases of the bones and neighbouring joints.

1. **Neuralgic Affections.**—Sciatica is a very common disorder, and the error is usually made of considering sacro-iliac disease to be sciatica rather than the reverse. It should be remembered, however, that sciatica appears in older people; that the pain runs down the leg and is not relieved by rest; and it is confined to the sciatic nerve and its branches. In sacro-iliac disease the pain is not so defined, and it is found also in the posterior branches of the lumbar

nerves and in the anterior crural and its ramifications. Still, when the sciatic nerve itself is involved in the disease within the pelvis, pain in that nerve trunk will predominate.

2. **Muscular Affections.**—On account of the diffusion of pain in sacro-iliac arthritis, ordinary lumbago has given rise to error. Here the pain is bilateral, and it is greatest over the lumbar region and not over the joint. It is usually very acute, yet transient. Affections of the psoas muscle, such as strains, are accompanied by flexion of the thigh on the pelvis, with inward rotation of the foot. This sign has never been observed in sacro-iliac disease.

3. **Affections of the Bones and Neighbouring Joints.**—These cause the great difficulty in diagnosis. If it be the ilium which is involved, we must carefully exclude symptoms of joint-involvement, and we must make a thorough examination by X-rays and other methods with the object of determining the exact site of the bone lesion. If sinuses are present, careful probing will often reveal a patch of carious or necrotic tissue.

It is easy as a rule to exclude tuberculosis of the vertebræ, except when the lumbar and especially the lower lumbar vertebræ are involved, and we must rely on the signs proper to spinal caries, with the absence of local tenderness over the sacro-iliac joint and of elevation of temperature. Then, too, if the sides of the pelvis are pressed together, no pain is elicited in the part. The attitude in the two diseases is totally dissimilar. The difficulty, however, of distinguishing between the two affections has arisen from the radiating character of the pain in both.

Hip-joint disease can be excluded by careful examination. The pelvis should be carefully steadied, and the movements of the thigh noted. If these are carried out with much gentleness, no pain will be elicited in the hip, but it is at once felt in sacro-iliac disease when the ilia are pressed together. A rectal examination quickly reveals the presence or absence of tenderness over the anterior aspect of the sacro-iliac synchondrosis in disease of that joint.

Relaxation of the sacro-iliac synchondrosis[1] has often been mistaken for sacro-iliac disease, and we have notes of six cases in which at first sight the resemblance was somewhat close. Constant pain in the lower part of the back is present, and it is almost

[1] "Further Studies of the Relaxation of the Sacro-Iliac Synchondrosis," by J. Dunlop, *Amer. Jour. Orth. Surg.* vol. v. No. 1, July 1907, p. 101; and "Sprain of the Sacro-Iliac Joint," W. J. Merrill, *Trans. Pennsylvania State Med. Soc.*, 1910.

invariably located by the patient over one of the sacro-iliac joints. It is usually a dull aching, varied by sharp knife-like pains. As a rule it is confined to one side, and even if both sides be affected the pain is greater on one side than the other. It is most marked in those attitudes which produce a strain on the articulation, such as going up and down stairs, sitting with the normal lumbar curve obliterated, lying in bed flat on the back, or even turning in bed, and it is often more severe on rising. Referred pains, too, are often present, especially in the gluteal region and about the ischial tuberosity. Very often a radiating pain is felt along the lower part of the abdomen and the groin; hence the diagnosis of chronic appendicitis has been made. With these symptoms it is difficult to distinguish relaxation of the joint from early disease. Although in some cases of relaxation a puffiness is noticed, yet the attitude is not that of arthritis. We have noted relaxation more often in the female sex; and we have found that where one joint is painful, asymmetry of the legs is present, and that the chief pain is on the side of the shorter leg, and is relieved by compensation. Pain on rectal examination is absent, and the ready way in which these cases yield to the application of a band of adhesive plaster or a strap round the pelvis is very striking. Sometimes, however, it is necessary to watch patients for a considerable period of time before a diagnosis can be made.

Prognosis.—In children the outlook is said to be more favourable than in adults. The main element in prognosis, however, is the formation of abscess. Thus in 16 cases of the dry form, the recoveries were 94 per cent; whilst in 38 cases of the moist or suppurating form the recoveries without operation were only 3 or 7·9 per cent. It therefore follows that much must depend upon the way in which the abscess cavity is treated and the thoroughness with which diseased bone can be eradicated. A further factor, too, is worthy of close consideration, that is, the avoidance of mixed infection after operation. In any case the prognosis in advanced sacro-iliac disease is decidedly unfavourable, death usually following from secondary tuberculosis or septicæmia. If the cases are seen early, and placed under treatment, the prognosis is favourable on the whole. Recovery takes place by ankylosis, which, however, may have a serious effect in parturition.

Treatment.—This consists of general measures suitable for all forms of tuberculosis, particularly the open-air treatment. The opsonic index will be taken, and the patient's resistance or absence of resistance to tubercle bacilli determined and vaccine used. In cases of mixed infection it is necessary to employ strepto- or staphylococcal vaccine first, and then tuberculin may be injected. Locally, the consideration of treatment resolves itself into two headings, that of the dry and that of the moist form.

In both forms we have to secure complete mechanical rest. It is best to place the patient at once in bed, preferably in a double Bryant's splint, or with weight and pulley extensions applied to the legs. If there is much pain present, counter-irritants or the thermo-cautery are of service. Until the wound from the latter is healed, the patient must be kept in the lateral position, and then either a Bryant's splint or weight-extension is put on. If progress is favourable, the plan adopted by Sayre may be followed. The patient may use crutches, with an elevated shoe on the sound side and a heavier shoe on the diseased side. Rest can be secured to the joint by a Thomas' double hip splint, made so that the main stems are at such a distance from each other that they will pass to the outer side of the posterior superior spines of the ilium, with a broad leather sling reaching from one stem to the other, and reaching from the coccyx to the mid-lumbar region.[1] In some instances the use of a leather girdle around the pelvis is helpful in relieving pain. It appears that the immobility secured, more than counterbalances the effect of crowding the diseased surfaces together. The use of the belt, however, is indicated more in the later stages of recovery than in the subacute stage.

Suppurating Form.—We do not advocate merely waiting on events in this serious condition, because we know of only one case of abscess, which has recovered under rest alone. Nor do we advocate simple drainage of the abscess. The older surgeons hesitated to operate because of the contamination which followed. It is, however, clear that in every case of sacro-iliac tuberculosis, where pus has formed, operative interference should be undertaken, and the operation must be radical. Extra-pelvic abscesses are more easy to deal with, and are more accessible, because it is the posterior part of the joint which is affected. The abscess should be opened, its walls scraped to remove tuberculous material, the opening leading into the joint cavity found and enlarged, and every particle of tuberculous material, whether of bone, synovial membrane, or periarticular tissue, taken away.

[1] Cf. Ridlon and Jones, *Annals of Surgery*, vol. xvii. p. 291.

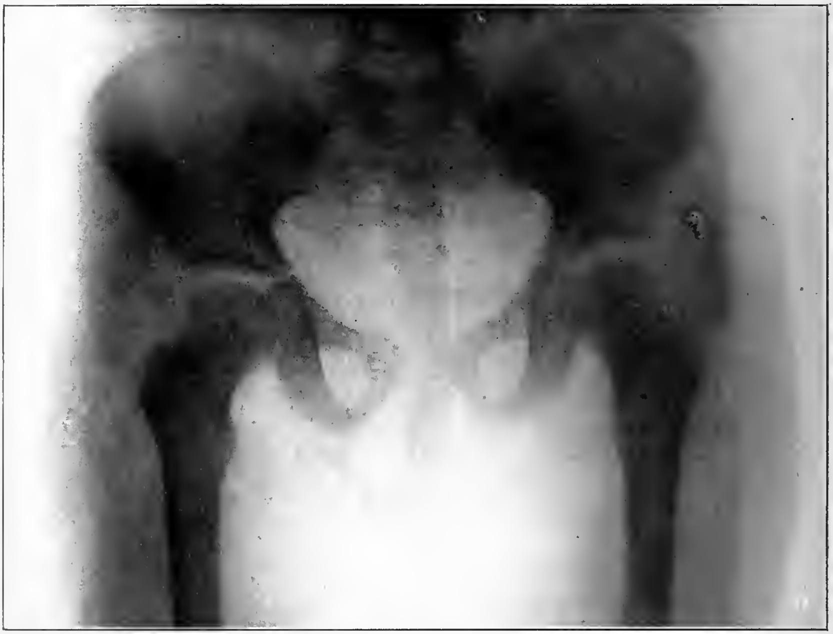
For intra-pelvic abscess Van Hook[1] has designed a systematic operation. "When the patient is lying on the affected side, with the thighs in exaggerated flexion on the pelvis, the site of operation will be brought into the greatest prominence possible. An incision, two or three inches in length, will expose to view the posterior spinous processes of the ilium, which should be freed from the periosteum and connective tissue by scraping with a dull instrument. A chisel is then used to remove successive small fragments from the exposed bone, preferably the ilium.[2] In this operation the strictest aseptic precautions must be taken, and a Bryant's splint or weight and pulley extension employed afterwards. A pelvic belt is especially valuable to hold raw surfaces of bone together."

To *sum up* the treatment. In the non-suppurative form absolute rest, counter-irritation, vaccines, and plenty of fresh air are called for. In the suppurating form radical operative interference is essential. Extra-pelvic abscesses should be opened, the joint explored, and every particle of tubercle removed. In dealing with intra-pelvic abscesses, the diseased focus should be attacked directly from behind, and the anterior part of the joint thoroughly cleared. If both extra- and intra-pelvic abscesses are present, the external abscess is first dealt with, then the joint is opened, and communication is made between the two abscesses through the joint by sufficient removal of bone, so that the deeper focus may be attacked. No attempt should be made to reach the diseased area through long sinuses; and scraping alone or drainage alone is totally inadequate to deal with the suppurative form of this serious disease. For many months after the operation, the patient must lie recumbent in suitable splints to effect a thorough cure by ankylosis.

[1] Weller Van Hook's articles are found in the *Annals of Surgery*, vol. viii. p. 401, and vol. ix. pp. 35, 115. Cf. also Collier, *Lancet*, 1889, vol. ii. p. 787; G. H. Makins, *Clin. Soc. Trans.* vol. xxvi. p. 127; and C. H. Golding-Bird, *Clin. Soc. Trans.* vol. xxviii. p. 186.

[2] "Always hold the edge of the chisel parallel to the spinous processes, so that the final cut enters the pelvis major, and palpate the anterior surface of the diseased joint. With curved bone-instruments the detritus can now be removed, and the wound packed with iodoform gauze."—Van Hook.

PLATE V.



Radiogram of Commencing Tuberculous Hip Disease, Right Side (Alban Köhler). The shadow of the head of the right femur is less well defined than on the left, and the intra-articular cleft is cloudy. Symptoms had existed for six weeks.

To face page 211.

PLATE VI.

Tuberculous Coxitis, Left Side (Alban Köhler). The head of the left femur is ill-defined, rarefied, especially at its upper and outer part, and the neck is thickened. Symptoms of coxitis had existed for nine months.

To face page 211.

CHAPTER VI

TUBERCULOUS DISEASE OF THE HIP-JOINT

(TUBERCULOUS COXITIS)

Ætiology—Pathology and Morbid Anatomy—Signs and Symptoms—Suppuration —Course of the Abscess—General Condition of the Patient during the Disease —Double Coxitis—Method of Examination and Diagnosis—Prognosis— Treatment, General and Local, Mechanical and Operative.

Synonyms—Hip-Disease, *Morbus Coxæ, Morbus Coxarius, Coxitis, Coxo-tuberculose, Coxalgie.* The last term is inaccurate and insufficient, as it means pain in the hip.

Ætiology

Frequency.—According to Whitman,[1] in a total of 7845 cases of tuberculous disease treated at the Hospital for the Ruptured and Crippled during 15 years from 1885-1899, 3203 were affected with Pott's disease, 2330 with hip-disease, while the remaining 2408 had disease of other joints and parts.

Age.—Whitman also found that of 1000 consecutive cases of hip-disease, 88·1 per cent were in the first decade of life, and of them 45·6 per cent were from 3 to 6 years of age.

Sex.—Boys suffer more than girls, the ratio being 55·3 per cent in males to 44·7 in girls. This is owing to the fact that boys are more active than girls, and run greater risk of injury.

Side Affected.—The right is more often diseased than the left side, in a proportion of 53 to 47 per cent.

The ætiology of tuberculous disease of joints is discussed in Section V. Chapter I., and need not be repeated.

Pathology and Morbid Anatomy

The disease usually begins in the upper part of the femur, less often in the acetabulum. The relative frequency of origin in the

[1] *Orth. Surg.* p. 224.

femur and acetabulum has not been satisfactorily determined,[1] but it seems clear that it is more often primarily femoral than acetabular. In children it always begins in the bony tissue;[2] whether it commences sometimes in the synovial tissue in adults is *sub judice.*

The first deposit of tubercle is generally seen in the epiphysis of the head of the femur, and in the neighbourhood of the epiphysial line as a tuberculous juxta-epiphysitis. Occasionally the distal side of the epiphysial line is affected. When the disease begins in

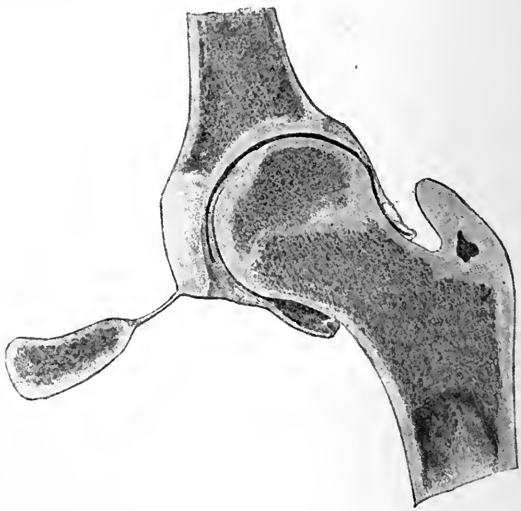


FIG. 113.—Section of the Hip-joint at the age of 8 years, showing the Epiphyses and the Relation of the Capsule (Schuchardt). At birth the entire upper extremity of the femur is cartilaginous. According to Jacinsky, ossification begins in the head of the femur at about the tenth month; in the trochanter major at from the fourth to the eighth year; in the trochanter minor at the eleventh year. Ossification is complete at all points at about the eighteenth year. Range of motion at the hip-joint. Extension to 20 degrees beyond the horizontal; flexion to 70 degrees; total 180 degrees. Abduction, adduction, and rotation are most free when the limb is flexed 60 degrees. At this point the range of adduction is 55 degrees, of adduction 35 degrees; total 90 degrees. Outward rotation 40 degrees, inward rotation 20 degrees; total 60 degrees. If the limb is completely extended, the range of abduction is about 40 degrees; adduction, 15 degrees (R. Du Bois-Raymond).

the neck, it usually makes its appearance on the under side,[3] so that in this event the focus may be either intra- or extra-articular.[4]

[1] Bradford and Lovett (*Orth. Surg.* 3rd ed. p. 84) state that the disease is primary acetabular in 25 per cent of cases.

[2] Ashby and Wright, *Diseases of Children*, 4th ed. p. 687.

[3] Ashby and Wright, *op. cit.* p. 688.

[4] Whitman has pointed out the relationship of tuberculous epiphysitis to some forms of coxa vara.

Unfortunately, in the latter case the process spreads too often to the joint, but not always, and some joints may be saved by early recognition of this fact.[1] If the acetabulum be primarily affected, the disease is both an epiphysitis and juxta-epiphysitis of the Y-shaped junction of the bones. So long as the disease remains confined within the articular portion of the femur, *i.e.* before perforation has taken place, the joint merely shows signs of

FIG. 114.

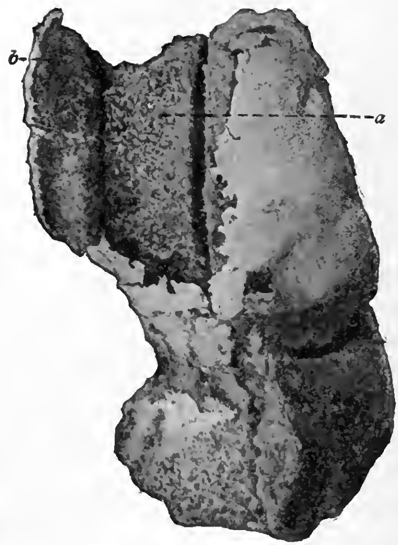


FIG. 115.

FIG. 114.—Tuberculous Focus in the Head of the Femur (Bradford and Lovett). The bone has been sawn through, and its anterior half has been turned upward.

FIG. 115.—Excised Head of Femur from a case of Tuberculous Coxitis. The articular cartilage is turned up at one side and shows tuberculous bone beneath. The primary focus was in the acetabulum, *a*, Head of femur, with numerous tuberculous nodules on its surface; *b*, articular cartilage elevated from bone (Nichols).

sympathetic irritation with increase of fluid within it. When the decrease invades the synovial membrane, it becomes thickened, granular, and reddened. The joint-fluid is opaque and puriform, and may escape from the joint into the soft tissues.

After the morbid condition has existed for a considerable time, and before repair has taken place, the joint presents the following appearances:—

[1] See article on "Para-Articular Tuberculosis of the Bones," vol. ii. p. 50.

The synovial cavity is irregular, and the membrane is thickened in some parts and ulcerated in others, or has caseous material adhering to it. In old-standing cases the membrane has disappeared altogether. The cartilage, or what remains of it, is loose, yellow, necrotic, and ragged, and peels off the bone, or lies detached in fragments in the pus. The bones are bare in places or entirely, and their surfaces vary in appearance. At times they are merely worm-eaten, or show irregular cavities filled with tuberculous material in various stages of degeneration. Sequestra are seen, of varying size, sometimes lying in lacunæ in the carious head or in the acetabulum, or loose in the joint cavity. In rare instances the head of the femur has been found necrotic and loose, forming a large sequestrum[1] (Fig. 116).

Fig. 116.—Tuberculous Coxitis. Separation of the head of the femur at the epiphysial line (Bradford and Lovett).

The head of the femur is eroded, irregular, and worm-eaten,—changes due partly to the disease and partly to intra-articular pressure[2] (Fig. 117). In severe and old-standing cases, disease is found in the epiphysis of the great trochanter, or at the upper part of the shaft, and in inveterate cases it extends into the shaft and medullary cavity as a tuberculous osteo-myelitis. The writer has been compelled to amputate at the hip for this cause, when persistent discharge and albuminuria are present.

The acetabulum is diseased either primarily or secondarily. It is generally rough and eroded, and softening goes on, so that its cavity

[1] *Clin. Soc. Trans.*, 1874.

[2] Whitman, *Orth. Surg.* 3rd ed. p. 223, notes that the loss of bone-substance is greater at the upper margin of the acetabulum, and upper and inner surface of the caput femoris, that is, at the spots where the muscular spasm causes the greatest pressure.

PLATE VII.

Early Tuberculous Coxitis, Left Side (Alban Köhler). The intra-articular portion of the femur is ill-defined and it is too transparent, especially the neck. The joint cleft is obscured, and the soft tissues in the neighbourhood are more dense than on the right. Symptoms had existed for one year.

To face page 214.

is widened, and permits upward displacement of the deformed femoral head. If this is gradual, a "wandering" acetabulum is formed

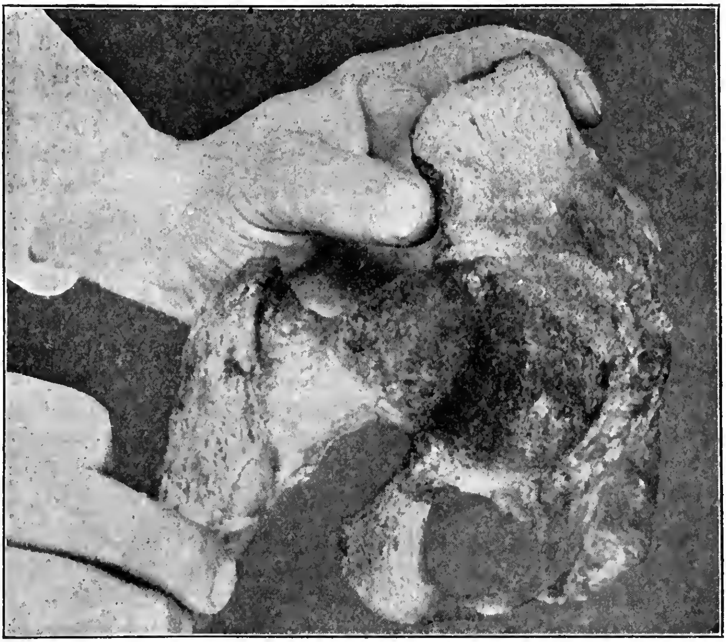


FIG. 117.—Erosion of the Head of the Femur and of the Upper Border of the Acetabulum. Formation of new bone (osteophytes) about the acetabulum (Royal Whitman).

(Fig. 119). If suddenly, and this is rare, true pathological dislocation arises. The deposit of new bone, however, around the area of disease usually prevents this, and dislocation is traceable to a sudden jar or to forcible movements of the limb. The acetabulum is frequently perforated, and pus enters the pelvis; but not all intra-pelvic abscesses are acetabular. Some are due to pus tracking up the psoas tendon, making its way by this muscle over the brim of the pelvis, and then migrating downwards.

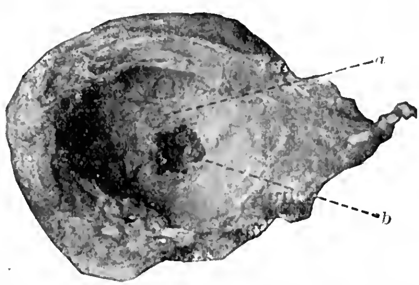


FIG. 118.—An Acetabulum, seen from outer side. *a*, Tuberculous granulations; *b*, tuberculous cavity (Nichols).

The destruction of the acetabulum is often severe, and the os innominatum may be separated into its component parts. If large sequestra form, and much of the bone is involved, extensive removal of the diseased parts is required.

The capsular ligament is softened and relaxed, and the round ligament is eroded and disappears. It is interesting to note that, in some instances of very early tuberculous epiphysitis of the head

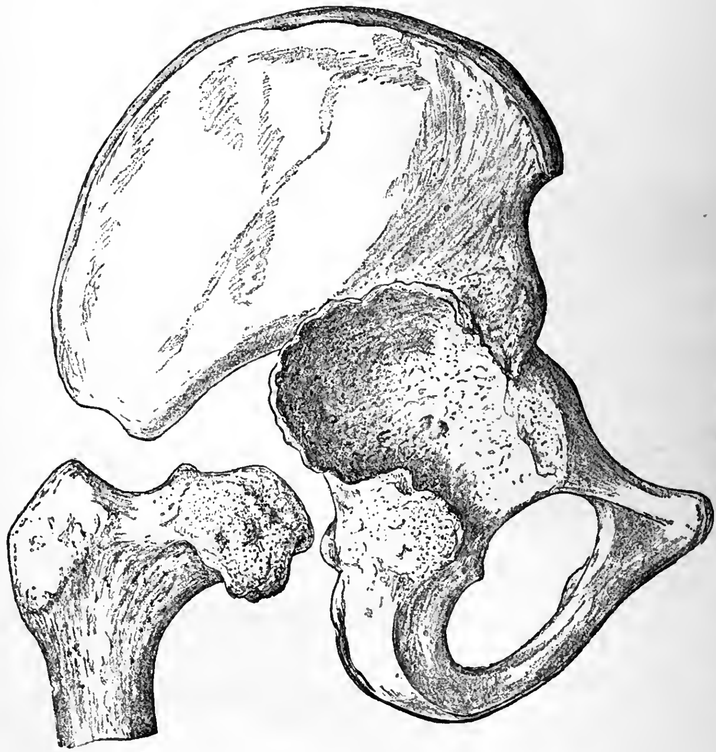


FIG. 119.—"Wandering" Acetabulum, due to "Intra-acetabular" Tuberculous Coxitis (E. Kauffmann). Note the lipping of the enlarged acetabulum, and the erosion of the head of the femur.

of the femur, the bursa beneath the psoas takes alarm and becomes filled with fluid. Such an event may happen before the movements of the joints have become markedly painful or limited.

Pus, at first pent up in the joint, bursts through the capsule, or perforates into the pelvis. In the first event it forms a peri-articular abscess, which may be felt in Scarpa's triangle, or in the proximity of the trochanter. If in the pelvis, it is readily detected by rectal examination. If not recognised early, it may open at

PLATE VIII.

Advanced Tuberculous Coxitis, Right Side (Alban Köhler). Whilst the shadows of the bones on the left side are clear, those on the right are very cloudy, indistinct, and thin; neither the outlines of the acetabulum nor of the head of the femur are distinguishable. The bones on the right side are much atrophied.

To face page 216.

almost any spot in the pelvic wall, or even work its way into one of the hollow viscera.

Repair and Natural Cure.—Whether occurring in the early or late stage, natural cure results either from the absorption or calcification and encapsulation of tuberculous material, or by the longer and more exhausting process of suppuration, separation of diseased bone, and evacuation and discharge of sequestra or of minute fragments of bone. This is accompanied by much distortion of the joint and deformity of the limb, and is succeeded by ankylosis. Repair, however, does not take place until the disease has ceased to be active, and then a considerable development of new bone may be found. Even when the disease is apparently cured, if an opportunity of examining the joints arises, a caseous focus partially encapsuled, yet showing signs of activity, may be met with; and under irritating conditions the disease may light up again.

FIG. 120.—Tuberculous Coxitis. Erosion of the cartilage of the head of the femur, and separation of the cartilage like a hood (Krause).

SYMPTOMS AND SIGNS

There are no cardinal symptoms of hip-joint disease, and no one symptom is present which may not be met with in some other disease in or about that region. The recognition of coxitis depends upon the order in which the symptoms and signs appear, and upon the particular grouping of them, "or symptom-complex," in an individual case. That this is so will be seen more fully when we discuss the diagnosis.

Owing to the numerous exceptions, it is not advisable to classify the symptoms into the three or four stages so time-honoured by surgical writers. We prefer to discuss them *seriatim* as nearly as possible in the order of their occurrence, and to indicate, so far as is possible, their diagnostic value.

Onset.—Except in very rare cases of acute suppuration[1] and after an injury, the advent of hip-disease is most insidious. The earliest sign is a limp[2] with which pain may or may not be associated. The limp is at first very intermittent in its appearance. It is often absent for two or three days together, and then re-appears after any unusual exertion or strain; but, as time progresses it is daily in evidence, the patient for a time being stiff in the morning, then becoming more free in gait, but limping in the afternoon; and then as the disease progresses, limping attracts serious attention by its persistence.

The limp is a conservative effort on the part of the child to save shock to the joint. He takes advantage instinctively of the elasticity of the knee-, ankle-, and foot-joints to shield the sensitive articulation. In walking, the hip is flexed and abducted, the pelvis is often tilted downwards on the affected side, the knee is flexed, the ankle extended, and the patient walks on the balls of the toes. If the case is allowed to continue its course, most of the following signs and symptoms will appear:—

Pain.—This is as a rule a prominent feature, and is due to intra-articular tension and pressure. It is a very variable symptom both in degree and position. As to degree, it is sometimes agonising, and accompanied by a high temperature and rapid wasting. At other times there is no pain, even in such an instance as recently came under the writer's notice, where a little boy aged six years was seen to limp on his left leg, which was found to be half an inch short. An X-ray examination showed that at least one-half of the head of the femur had disappeared, and there were also signs of an abscess just in front of the great trochanter. Yet, the little fellow

[1] Ashby and Wright, *op. cit.* p. 690.

[2] Note the instructive remarks on this subject by Dr. Le Roy Hubbard, *Amer. Med. Surg. Bull.*, Jan. 11, 1896.

PLATE IX.

Radiogram of a case of Tuberculous Coxitis, Left Side, chiefly Acetabular, taken after the disease had existed for 18 months. The acetabulum is destroyed, whilst the head of the femur is fairly intact, its ossific nucleus being present. Sub-luxation at the joint has taken place.

To face page 218.

was running and jumping about in the most unconcerned way. In most cases, however, severe pain persists until the child is placed under adequate treatment; and it may not then subside for a long time. Bradford and Lovett[1] point out that the joint may be perfectly stiff from muscular spasm, yet manipulation is wholly painless. They further add, which is a point well verified by others, that motion to a certain degree may be painless, and when this point is passed, further movement is prevented either by pain or muscular fixation. In neglected cases the pain is often so great when they first seek advice that the merest touch or jar causes agony. Some children will lie in bed with the foot of the healthy limb placed on the dorsum of the opposite foot, in order to push it downwards, and lessen intra-articular pressure (Fig. 121). Occa-

FIG. 121.—Instinctive efforts at traction, to relieve the pain of acute tuberculous coxitis (Bradford and Lovett, from Fisk Prize Fund Essay).

sionally, pain is elicited by one particular movement only, such as extension or abduction.

The *site of the pain* is also variable. Probably the most common situation is over the front and inner side of the knee. The localisation of it in this situation is due as much to the connections and supply of the anterior crural as to the obturator nerve. Pain may be referred to any part of the thigh, the buttock, knee, leg, or foot, or is felt only in the diseased joint itself. Pain in the knee alone is not so common as the text-books lead us to infer.

Night Cries.—They indicate that the disease has spread to the articular surfaces from the interior of the bone. To be more exact, the night-cries imply ulceration of cartilage. Two remarkable cases occurred at the Hip Hospital, Sevenoaks. In one case the head of the femur was found to be a simple shell, but with the cartilage

[1] *Op. cit.* 3rd ed. p. 91.

intact, and in this instance no night-cries had been heard, although the case came to operation for other reasons. In a second case, where night-cries were incessant and distracting, the cartilage alone was found extensively ulcerated.

It is unusual for night-cries to last for several months after the patient has been put to bed with weight-extension applied, yet in one rare instance at the same hospital they continued at intervals for eighteen months, and in another patient they ceased with the sudden appearance of an abscess. They are due to involuntary and unguarded movements of the muscles during sleep, which bring sensitive and diseased parts of the joint together. "Night-cries" and night-startings are heard or seen in the comparatively early stages of the affection. They may occur as many as fifteen to twenty times in one night, and usually in the early part of it. If the case is under treatment by weight-extension, the night-cry indicates that there is not sufficient dis-traction of the joint, and an increased weight must be used. In some instances the pain is not sufficient to wake the patient, and he may moan in his sleep or be restless, and talk of nightmare in the morning. In other instances the pain is so severe as to wake the child with a start, and the poor little sufferer is found sobbing and holding the limb with the hands, or steadying it with the other leg.

Tenderness.—Distinct tenderness is felt on pressure over the front of the joint in Scarpa's triangle, and over the trochanter in acute conditions. It is increased, but not always, if an abscess forms. The attempt to elicit pain in the joint by jarring the foot, or by sudden pressure on the trochanter, is barbarous and entirely unnecessary.

If the tenderness on pressure is found over the head of the bone only on deep palpation, Wright[1] says, "It is probable that the disease is limited to the head of the bone, and has not yet set up mischief of a serious nature within the joint, or at least that any such change is a very chronic one." He warns us, however, that such tenderness may also be due to inflammation of the capsular ligament, which has spread from the bone to it. Tenderness is more marked in some movements of the joint than in others, thus flexion may be painless, whilst abduction with rotation or hyper-extension is very painful.

Such are the early signs of the disease. We must now consider the aspect of the case when the disease has been in progress for some time.

[1] *Op. cit.* p. 692.

Lameness.—The limping, at first intermittent, becomes constant, and the child shows the characteristic gait. The rhythm is a long step alternating with a short one. The causes of the lameness are pain, flexion, tilting of the pelvis, and shortening, apparent or real, the last coming on late in the disease.

Muscular Spasm.—Limitation of the movements of the joint *in any degree* and *in any direction* should excite suspicion. Spasm is the first sign to appear and the last to disappear. It affords an index of the success or otherwise of treatment. Briefly, we may say that if in a child who is placed on the back, both limbs can be fully flexed and extended at the hip, then completely abducted and rotated outwards, and finally adducted and rotated inwards (Figs. 122, 123), all without causing movement of the pelvis or lordosis, or any expression of pain on the child's face or by word of mouth, then that child is free from hip-joint disease. To ensure the thoroughness of the test, the child should also be placed in the prone position and the hips hyper-extended. It is to be noted that in severe hip-joint disease this latter manœuvre causes the spinal muscles to become rigid, so that a suspicion of Pott's disease may be raised.

Muscular spasm may be found in some cases only towards the extreme of the arc of motion in any one direction, whilst in other cases it is so marked as to simulate ankylosis. When an examination is made under deep anæsthesia, all the spasm disappears, only to return gradually as the patient recovers consciousness. In some instances there may be 10° or 15° of free flexion, and then the movement is checked; in other cases flexion and abduction, or flexion and adduction, are found to be limited; in yet others full extension is impossible. These variations are dependent upon which part of the head and neck of the femur or acetabulum is the site of the disease; and spasm becomes marked so soon as the tuberculous focus has spread to the synovial membrane and cartilage.

A simple and painless method of ascertaining if spasm is present in a suspected and painful limb, is not to manipulate the affected limb, but to place the patient squarely on the couch, and flex, extend, abduct, adduct and rotate the sound limb. If there be any rigidity present in the suspected hip, it will be raised from the couch, as the spine is pressed firmly on the couch by the extreme flexion of the sound limb (Thomas' sign) (Fig. 133). Similarly, movements of abduction in the sound limb will be accompanied by adduction in the affected limb, and adduction by abduction.

FIG. 122.

FIG. 123.

To show the Rotation- and Abduction-Test for Tuberculous Coxitis. In Fig. 122 the test shows the range of flexion and abduction in the normal hip. In Fig. 123 the range of mobility is decreased (Young).

The causation of the muscular spasm is twofold. Reflex action is one, and another is the voluntary effort on the part of the patient to prevent any friction of the painful articular surfaces.

Fixation.—This can be distinguished from muscular spasm by an examination under an anæsthetic. It is due either to adhesions in or around the joint (fibrous ankylosis), contracture and shortening of tendons, or to bony ankylosis. It is only found in the later stages of the disease or in cured cases.

Atrophy.—Early atrophy of the muscles of the hip, thigh, and leg is a constant sign. It is not due to disuse only, for it is greater in the affected than in the sound limb if the patient has rested from the first. It is also out of all proportion to the length of time during which the patient has ceased to walk about. And as Bradford and Lovett point out, the muscles, though atrophied, are not soft and flabby, but tense and firm. It is one cause of the partial obliteration of the gluteal fold. With the atrophy there is diminished reaction to the faradic current,[1] *i.e.* in order to produce a response to stimulation of the muscles of the diseased leg and equivalent to the response in the muscles of the sound leg, a stronger current is required in the former than in the latter. The patellar reflex is also decreased, pointing to some change in the so-called "trophic influences." It would be interesting to observe if the nerves were the seat of tuberculous neuritis. The bones also suffer, the compact layer becoming thinned, and the cancellous tissue rarefied. When this atrophy is limited to the neck of the femur it is one of the causes of coxa vara. In old standing cases the hip becomes bulbous, while the thigh and leg are spindle and shank-like, and the venous and lymphatic circulation are obstructed.[2]

Retardation of growth of the bones, associated with hip-disease in childhood, has been the subject of investigation by Brackett,[3] Döllinger,[4] H. L. Taylor,[5] and Hibbs.[6] The loss appears to be

[1] Cf. Shaffer, "Neuro-Muscular Elements in Coxitis," *N.Y. Med. Journ.*, Feb. 24, 1900.

[2] Alexandroff, *La Presse médicale*, Dec. 9, 1896, calls attention to the atrophy and fatty degeneration of the muscles and bones; and more particularly he refers to the hypertrophy of the subcutaneous cellulo-adipose tissue (Alexandroff's sign in early diagnosis), which he states exists in every stage of the disease from the first to the last, and increases with the gravity of the case.

[3] *Trans. Amer. Orth. Ass.* vol. iv.

[4] *Zeitschr. orth. Chir.* Bd. 1, 1892.

[5] *Trans. Amer. Orth. Ass.* vol. xiii. 1900.

[6] *N.Y. Med. Journ.*, Dec. 16, 1899.

proportionate to the duration of the disease and the length of time during which the functions of the limb are in abeyance.

Alterations in the Outline of the Region of the Hip.—The chief points to be noted are changes in the fold of the groin, and flattening and widening of the buttock, with lowering and partial obliteration of the gluteal fold (Fig. 124). The groin-fold in coxitis disappears when the limb is abducted and rotated outward, and it is deepened when the limb is adducted and rotated inward; in the latter case the labium majus in girls is partly hidden and compressed, and intertrigo sometimes occurs. As to the gluteal fold, if the limb is flexed, abducted, and rotated outward, the fold is lowered, because of the downward tilting of the pelvis, and it is shallower because of the flexion and muscular atrophy. On the other hand, if the limb is flexed, adducted, and rotated inward, the gluteal fold is elevated and shortened. The genitals and rima natium point towards the adducted and away from the abducted thigh. Adduction also brings the great trochanter more into evidence, and abduction obliterates it. The effects of atrophy on the contour of the hip and thigh have been referred to. The thickening of the tissues from infiltration, either of inflammatory origin or by the formation of caseous material, accounts partly for the loss of the fold of the groin. And this loss is the more marked if, as sometimes occurs, the inguinal glands are enlarged.[1] A fulness in Scarpa's triangle is indicative either of pus from the joint or of bursitis of the psoas bursa. Mr. D'Arcy Power has pointed out that the earliest sign of tuberculous hip-disease may be a chronic enlargement of the psoas bursa. The significance of swelling of the inguinal glands is considerable; and if well marked,

FIG. 124.—Obliteration of the Gluteal Fold in Tuberculous Coxitis of the right side (Bradford and Lovett).

[1] Kirmisson, *Diff. acquises*, believes enlargement of the lymphatic glands in the groin to be one of the most important early signs, and we agree with him.

the indication is that, according to G. A. Wright,[1] the pelvis rather than the femur is diseased.

Thickening of the trochanter is a valuable sign, and again, according to G. A. Wright, is symptomatic either of suppuration or caseation in the joint. The writer's observations agree mainly with this view, but he also believes trochanteric thickening to be indicative of pus within the bone, even before it has made its way into the joint. Enlargement has certainly been found in caseous disease in the neighbourhood of the epiphysial line before the joint has become involved. Wright further believes that the thickening, even though it may disappear under treatment, is an indication of the possibility of relapse, as doubtless more or less dry caseous material has been left behind in the bone and joint.

Distortions of the Limb.[2]—These consist of *a*, flexion, abduction, rotation outward, and apparent lengthening; *b*, flexion, adduction, and apparent shortening; *c*, flexion, adduction, and real shortening; and with them lordosis of varying degree co-exists (Figs. 125-131). Generally these positions, taken in the order in which they are here named, are indicative of the stage of the disease; but this statement is not entirely correct, as there are numerous exceptions, and it is often misleading. Thus, in the so-called first stage *a*, flexion and rotation outward, but no abduction may be present; or flexion, abduction, and rotation inward may be seen.[3] In the second stage *b*, abduction and rotation outward are often seen, or adduction with flexion, but without rotation, is noted. And even in the third stage *c*, abduction and rotation outward are sometimes met with. Thus it is clear that the position of the limb does not always indicate the stage of the disease.

Flexion, Abduction, and Apparent[4] **Lengthening with Lordosis.**—Flexion and lordosis (Fig. 125) are the complements

[1] *Op. cit.* p. 693.

[2] Cf. a most instructive and original paper by H. M. Sherman on "Position-Symptoms in Joint Disease," *Trans. Amer. Orth. Assoc.* vol. xii. p. 184.

[3] Kirmisson, *Difformités acquises.*

[4] The abducted limb looks longer, on account of the tilting of the pelvis, but is, when measured from the anterior superior spine, actually shorter. French authors call this the "paradoxe de la coxalgie." It may be explained by the diagram (Fig. 128, p. 227):—A A′ = the anterior superior spines; B B′ = the acetabula; B C′, B′ C‴ = the femora, parallel to one another, and to the vertical line, B C′ being in abduction and B′ C‴ in adduction to a corresponding degree. At B C the femur is still more abducted, at B C″ it is adducted. As angle A B C is less than angle A B C′, and angle A B C′ less than angle A B C″, A C is less than A C′, and A C′ less than A C″. That is, the actual measurement from the anterior superior spine to, say, the internal malleolus is less in the abducted than in the adducted limb. It is supposed in the diagram that

of each other. Flexion is due to reflex muscular irritation; and it is also voluntary in order to reduce the shock and jar on the sensitive limb in walking. Abduction, apparent lengthening, and downward tilting of the pelvis (Fig. 126) are associated

FIG. 125.—Right-angled Flexion in Hip-Disease, partly concealed by the compensatory lordosis and by the flexion at the knee and ankle (Royal Whitman).

FIG. 126.—Apparent Lengthening. When the abducted limb is brought to the median line, the pelvis is so tilted that it seems longer (Royal Whitman).

mechanically. The causation of the abduction has been much discussed, and it has been stated to be due to filling of the joint

there is no erosion of the head or pathological dislocation on the affected side. That is to say, the limbs are of equal length when arranged symmetrically to the mid-sacral line.

with fluid and to other causes. Yet this does not explain the fact that in some cases in the earlier stage adduction is present. The distorted positions are due to the patient both consciously and unconsciously finding which attitudes give him the greatest amount of relief from pain, whether he is standing, sitting, or lying. However, as the joint-irritation increases, the more powerful adductors overcome the abductors, and this fact explains the greater frequency of adduction when the disease has become fully

FIG. 127.—Apparent Elongation of the lower extremity in left Tuberculous Coxitis, due to abduction of the limb, and the necessary tilting upward of the pelvis on the sound side, so as to allow the abducted limb to be brought into a line with the trunk (Bryant).

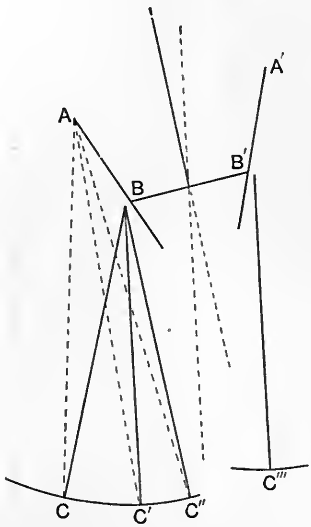


FIG. 128.—La Paradoxe de la Coxalgie. For explanation see foot-note 4, p. 225 (Vincent Moxey).

established. It is quite probable that the answer to the question as to the predominance of one position of deformity in the early stage depends upon which part of the head of the femur or of the acetabulum is diseased. In some cases abduction relieves the pressure on the tender spot, in others adduction. It would be interesting to work this point out by clinical and pathological observation.

Flexion, Adduction, and Apparent Shortening with Lordosis and Upward Tilting of the Pelvis on the Diseased Side (Figs. 129, 130), are also mechanically combined, and so too are flexion, adduction, and *real* shortening. The last named (Fig. 131) is due to partial or entire absorption of the head of the femur, widening of the acetabulum, and wearing down of its

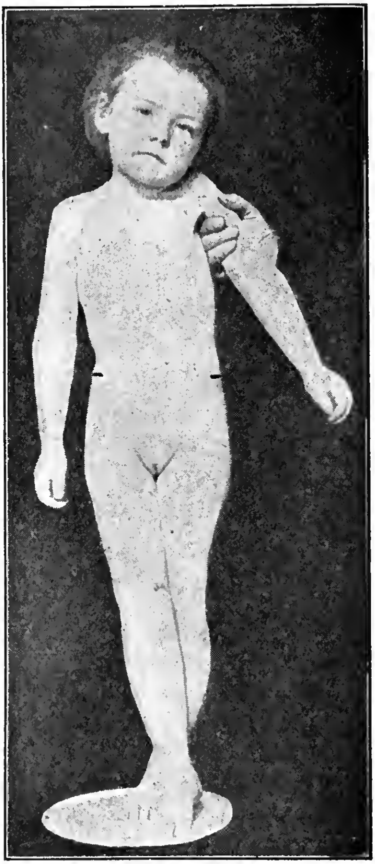


Fig. 129.—Apparent Shortening. The adduction of the right thigh is made evident by the involuntary crossing of the legs when the anterior superior spines are in the same plane (Royal Whitman).

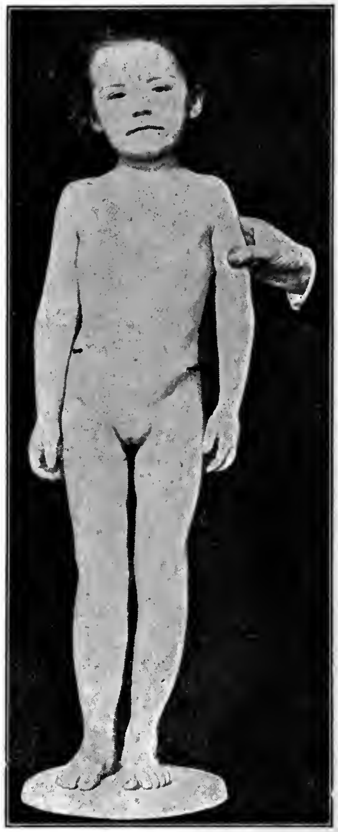


Fig. 130. — Apparent Shortening. When the adducted limb is placed in the line of the body, the pelvis is tilted upward on the adducted side and downward on the other. The patient has compensated for the apparent shortening by flexing the knee on the sound side. This does not appear in the photograph (Royal Whitman).

prominent postero-superior rim, so that the remains of the upper part of the femur are gradually crowded upwards by the persistent muscular spasm. Some of the real shortening is also accounted for by the atrophy of the bone and retardation of growth, which becomes more marked as time elapses, and even after the disease is cured. In rare cases, real shortening is due to true dis-

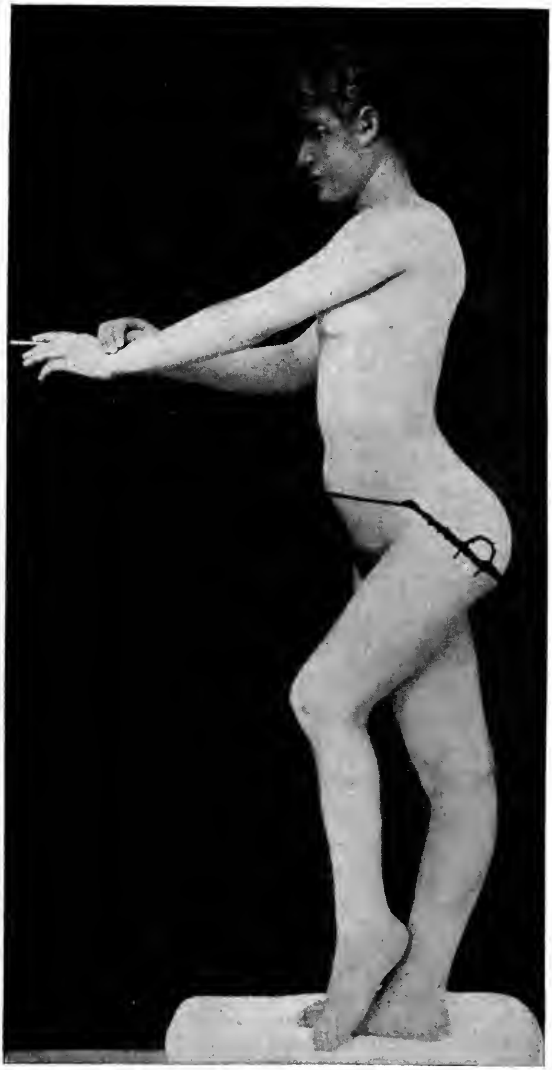


FIG. 131.—Flexion, Adduction, and Real Shortening of the left lower limb, with elevation of the left great trochanter, lumbar lordosis, and genu recurvatum of the right knee (Julius Döllinger).

location following violence or a fall on to a diseased hip.[1] The

[1] Kirmisson, *Rev. d'orthop.*, Nov. 1, 1899, says that "rarely sudden dislocation of the hip may occur in coxitis apart from any marked change in the articular surfaces ;

extent of true bony shortening from changes in the joint are ascertained by tape-measurements[1] from the anterior superior spines of the ilium to the internal malleoli, and by observing carefully the relationship of the top of the great trochanter to Nélaton's line, taken with the hip slightly flexed. If the upper margin of the trochanter be above this line, then real shortening at the hip will be present (Fig. 131).

Grating and Crepitation.—These signs can as a rule only be found when an examination is made under an anæsthetic. Usually the joint is much too painful to attempt to elicit them whilst the patient is conscious. When present, they are pathognomonic of diseased bone in the joint, and they are due either to loss of cartilage on the head of the femur or the acetabulum, or both; to separation of the head of the femur and friction against the diseased neck; or to the attrition of sequestra of appreciable size in the joint.

Swelling and Peri-articular Changes are found in the early stages of the disease as an infiltration of the tissues around the joint, or as localised thickenings deep down in Scarpa's triangle, or behind the great trochanter.[2] The thickening of the trochanter and its significance have already been adverted to. The inguinal glands are often enlarged and may suppurate. They are usually affected in pelvic disease, especially one which is felt lying on the external iliac vessels just behind Poupart's ligament.

When the disease has existed for some time or has become acute, the whole of the peri-articular tissues are seen and felt to be œdematous, and such œdema may ultimately break down in places into pus. In acute and subacute cases the temperature of the part is increased, particularly if deep-seated pus is present.

Dislocation in the true sense of the word rarely occurs. It is

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and this is analogous to the dislocation occurring during convalescence from some acute general disease."

[1] So apparently simple a matter as taking measurements requires much care to ensure accuracy. The first point is that the patient's knees must be fully extended, and in the case of a child held so by the nurse or attendant. Then, it is not sufficient merely to feel for the bony joints with the fingers and plant the tapes on them. The points must be carefully verified and marked in ink. In measuring, the tapes should be held above and away from the skin, over the ink marks, and must not touch them. In a child, the anterior superior spines are often deeply buried, more internally placed than in the adult, and partially concealed by fat. Want of care in carrying out these simple details makes sometimes as much as one-quarter of an inch difference in the measurements.

[2] According to Bradford and Lovett, this is a sign of great value in the early recognition of the disease.

rather a condition of gradual sub-luxation of the diseased femur, and hence the occasional appearance of wandering acetabulum.

X-rays.[1]—In the early stages the passage of these rays is less free than in the normal hip, and the part appears hazy and the structure of the bone is ill-defined. This may be due either to greater vascularity of the part, or, as is more probable, it arises from the microscopic thickening of the bony trabeculæ preceding tuberculous infiltration, as described by Sir Watson Cheyne. Later in the disease, localised patches of tuberculous material can be identified both in the negative and print, and the alterations in the contour of the head, its size and position, can be easily recognised. The effects of tuberculous softening of the neck, causing one form of coxa vara, are occasionally seen. Changes in the acetabulum are also demonstrable (see Plate IX.).

Examination per Rectum.—It has been well said that the key to the condition of the pelvic bones in hip disease lies in digital examination of the lower bowel. In every case this should be done, whether pelvic disease be suspected or not.

Abscess.—Unless the disease is placed under efficient treatment early there is a great probability of pus forming. At the Sevenoaks Hospital for Hip Disease the proportion of cases admitted with abscess was 24 per cent, and 10 per cent subsequently developed it (G. Sichel). A sterile abscess, or rather one of unmixed infection, is not of very grave importance to the patient, but the outlook is very different when a tuberculous abscess has become infected with septic organisms. Rapid extension of caries and necrosis often follows, and the patient's general condition steadily deteriorates.

Ashby and Wright state that "nearly every case of chronic disease of the hip, if not cured in an early stage, would be found, if the joint were examined, to contain pus or puriform fluid at a certain period of its course." This remark is a little vague, yet it reflects the opinion of authors of wide experience, and is therefore entitled to respect. Still it is quite certain that not all the puriform collections which form in connection with the joint make their appearance externally as abscesses. Very often caseous deposits remain, and they constitute the chief causes of relapse even after long intervals of quiescence and apparent cure. Abscesses are in the majority of cases primarily intra-articular; yet a few are extra-

[1] See also Lovett and Brown, "Diagnostic Value of X-rays in Hip Disease," *Philad. Med. Jour.*, 28th January 1905.

articular, and originate on the shaft side of the epiphysial line of the neck, and may or may not enter the joint.

When pus has formed in the joint cavity, it usually makes its way through the posterior part of the capsule, its weakest part, and then migrates. The various situations where fluctuation can be detected or pointing takes place are as follows:—

(*a*) Pus, leaving the joint, creeps beneath the rectus femoris and presents itself at the anterior border of the great trochanter.

(*b*) It may, instead of opening just in front of the trochanter major, travel for a variable distance down the thigh, and point just above the termination of the muscular fibres of the tensor vaginæ femoris.

(*c*) Its course is sometimes posterior, and it may point either at the posterior margin of the trochanter major, or

(*d*) At the lower margin of the gluteus maximus.

(*e*) Sometimes, pus gravitates inwards, and the abscess is felt at the inner side of the thigh, in the fold between the genitals and groin.

(*f*) It extends along the adductor tendons and opens on the inside of the thigh.

(*g*) It travels up the sheath of the psoas and points above Poupart's ligament, or, descending thence over the brim of the pelvis, it drops into the cavity, and opens either into the rectum, ischio-rectal fossa, bladder, or through the sciatic notch.

(*h*) An intra-articular abscess, particularly if due to primary acetabular disease, may perforate the floor of that cavity and enter the pelvis directly.

(*i*) Lastly, pus may travel a considerable distance and open at a more remote spot, such as the popliteal space.

By way of comment we may add that the site of the primary lesion cannot be inferred with any certainty from the position of the abscess; although, the more marked the thickening to be felt by deep pressure above Poupart's ligament, the more likely is it that acetabular and pelvic disease are present; and this becomes a certainty if by rectal examination a thickening of the inner wall of the pelvis is felt. Ashby and Wright also think that suppurating glands are suggestive of acetabular disease, and that sinuses in the groove between the genitals and thigh indicate pelvic disease. Our experience confirms this view of the matter.

It must not be overlooked that some peri-articular abscesses are also due to suppurating glands or the breaking down of tuberculous bursæ. Not every case coming late under treatment suppurates, nor do all those run a disastrous course which, though coming early, are subjected to inefficient treatment. In some instances the diseased bone disappears by dry caries or caries sicca. Often, however, the appearance of an abscess is indicative of delayed or inefficient treatment, or want of conscientiousness and thoroughness in carrying out details.

Pus-formation is not necessarily accompanied by increased constitutional disturbance, although locally, spasm, aggravation of rigidity, and pain are characteristic of its presence. It often happens that when an abscess has been opened or has discharged spontaneously, the patient's condition is improved, and remains so for so long a time as free discharge takes place. If, however, the pus becomes pent up the general health deteriorates, more particularly if the abscess cavity is infected with pyogenic organisms. Such abscesses may continue to discharge for months or years through one or several sinuses and eventually heal, or they may refuse to do so because the extent of carious and necrotic bone is too great, particularly in the case of pelvic disease.

Even when fluctuation can be felt beneath the skin, absorption may take place and the swelling disappear, perhaps leaving a depression beneath the skin.

A residual abscess oftentimes lights up and gives rise to troublesome secondary abscesses, which should be boldly dealt with by free incisions and scraping, and immediate closure of the cavity.

General State of the Patient during the Disease.—Whilst a few patients appear to retain their general health for a time with hip-joint disease, the majority are ailing from the first. The onset of the disease is accompanied by general malaise, the child becoming pale, listless, thin, and gradually losing his appetite, and there is pyrexia in the evening. When pus is pent up in the joint, or is tracking through the soft tissues, the temperature is usually raised, the general loss of health is more rapid, and the child's face is often wizened and prematurely aged, whilst his expression is that of one in constant pain. Disturbed sleep at night adds to the general misery. Nevertheless, it is astonishing how soon an improvement sets in after the free evacuation of pus, unless there is extensive caries and necrosis of the pelvic bones, or tuberculous osteomyelitis is extending into the shaft of the femur.

Remissions.—Bradford and Lovett rightly dwell upon this aspect of the disease. It is during the early period that remissions are most marked, and we have known a skilled surgeon deceived by them. We saw an early case in a boy aged 9 years, and, at the time, the signs present were limping, loss of the gluteal fold, and some loss of complete flexion and pain. We gave it as our opinion that tuberculous coxitis was present. The surgeon in question was called in, and saw the boy three days afterwards with us. In the meantime the boy had been resting in bed. The symptoms present on the first occasion had all disappeared, even the gluteal fold was in no wise different from the other, and every movement was free and painless. Our friend gave it as his opinion that, as no signs were present, no coxitis existed. A few days afterwards all the symptoms had returned, and persisted for over twelve months. Then tuberculous choroiditis developed.

Remissions even of days or weeks are most marked in the early stages, and it is then that so much valuable time is lost and harm is done by want of careful and thorough treatment. Even when the disease has become fully declared and the patient has not been under treatment, occasional improvements in the symptoms occur.

Double-Hip Disease.—This is of interest because of the resulting "scissor-legged deformity." The disease is often severe and ends in ankylosis. We have seen three cases with double-hip disease and spinal disease. Such a combination is rare, spinal caries more often co-existing with disease of several small joints rather than of one or two large joints.

Method of Examination and Diagnosis

An inquiry should be made into the child's antecedents and history, not so much because they are of value in determining the nature of the disease, but on account of the fact that slight injuries to a child of tuberculous parentage are frequently the precursors of joint-disease. It is well also to ask if there has been any deterioration of the general health, and to observe for one's self if malaise is present.

The examination may then be made, and before doing so and whilst carrying it out every effort is to be used to enlist the child's sympathy and confidence. Above all, no vigorous nor forcible movements should be attempted by the surgeon, every manœuvre being carried out with gentleness and deliberation.

Physical Examination.—The child is asked to walk the room, and the presence or absence of a limp noted. Its absence at times in the early stages is well known, and its remission is apt to deceive the unwary.[1] The rhythm of the walk is typical, and has been referred to on p. 221.

The clothes are then entirely removed, and the walk is again noted, also the changes in the contour of the hip, the state of the inguinal and gluteal folds, the partial hiding of the genitals by the thigh, the wasting of the gluteal region, and thigh, the presence or absence of lordosis, and of abduction (Fig. 132) or adduction (Fig. 130).

FIG. 132. — The position assumed in standing, with slight abduction of the right leg (Bradford and Lovett).

The child is then placed supine on a firm couch or table, and the relative length and size of the limbs observed. Care should be taken to place the child so that the line joining the anterior superior spines is exactly at right angles to the median line of the body; and to assist the eye, the skin over the spines should be marked in ink. With the pelvis squarely placed, it can be seen at once if abduction or adduction is present. Normally, in the supine position the lumbar spines and the popliteal surfaces of the knees nearly rest on the table at the same time. If the lordosis is at all marked, flexion at the hip is present.

Then the movements of the joints are tested. The H. O. Thomas' test is very useful (Fig. 133). It is always wise to begin with the sound side, partly in order to secure the child's confidence, and partly because valuable information can be gained. If, when the sound limb is fully flexed on the abdomen so as to

[1] Shaffer, *Trans. Amer. Orth. Assoc.* vol. xv., 1902, mentions a case where a limp came and went seven times before the diagnosis was sufficiently pronounced. H. L. Burrell of Boston, U.S.A., and other writers have fully discussed the intermittent character of the limp.

press the lumbar spine on the table or couch, the suspected limb rises, then flexion is present at its hip-joint, and the angle of flexion can be estimated (p. 241). Further, if pulling down or pushing up of the sound limb are required to bring the pelvis level, then abduction or adduction exists.

The movements of the suspected limb are carefully examined and the chief sign of hip-joint disease is sought for. This is, in the words of Bradford and Lovett, "the *presence of stiffness in the joint or limitations of its proper arc of motion.*" The movements must be carried out with the utmost gentleness, and very gradually, and the child's attention is distracted, if possible, at the time. Any roughness or sudden force provokes resistance and pain, and the patient

FIG. 133.—The H. O. Thomas' Test, for the Estimation of the Degree of Flexion of the diseased leg (here the left) in Hip Disease (Bradford and Lovett).

actively contracts the muscles to protect the joint. The limitation of movement observed, when the manœuvre is properly conducted, is reflex and unconscious, and is due to tonic contraction of the muscles. It disappears under an anæsthetic. The order in which the movements are examined and the method is this: The surgeon places one hand on the child's pelvis in order to note any movement in it, and with the other he gently takes hold either of the ankle or the knee, and first flexes, and then abducts and rotates outwards, then adducts and rotates inward, and then extends the limb at the hip (Fig. 134).

Limitation of flexion is noted either by placing one hand on the sacrum, and observing the angle of the thigh at which it commences to move; or movement of the pelvis is felt by the hand resting upon the iliac crest.

Limitations of abduction and of adduction cause movement of the anterior superior spines, when the affected limb is drawn inward or

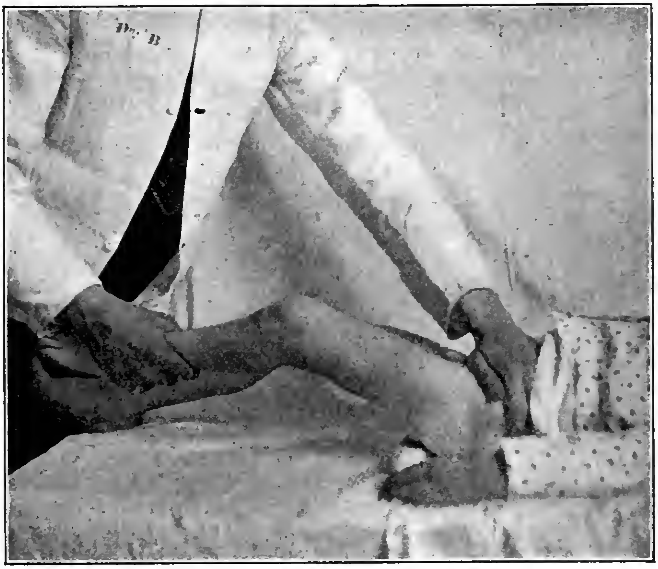

FIG. 134.—A Method of examining a hip-joint (Bradford and Lovett).

outward, the pelvis moving with the limb. Lessening of rotation is best appreciated with the thigh flexed at a right angle. Loss of com-

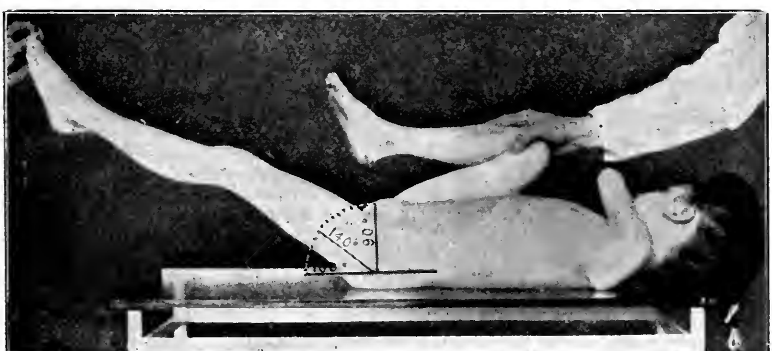

FIG. 135.—The Degree of Fixed Flexion is shown when the lumbar spine is held in contact with the table by flexing the other thigh (Royal Whitman).

plete extension is tested with the child in the prone position (Fig. 136). In the normal hip-joint, with the pelvis held flat on the table, the range of extension is at least ten degrees backward from the line of the body. Early limitation of this movement is most significant, so too is a decreased angle of abduction and of rotation. Any loss of movement is suspicious, however slight it may be.

FIG. 136.—A Method of determining the Limitation of Extension in Disease of the Hip (Bradford and Lovett).

As the disease progresses, movement is more and more restricted, and when due to fibrous or bony ankylosis, complete passive movement is impossible under an anæsthetic.

After noting the above points by palpation, the surgeon determines

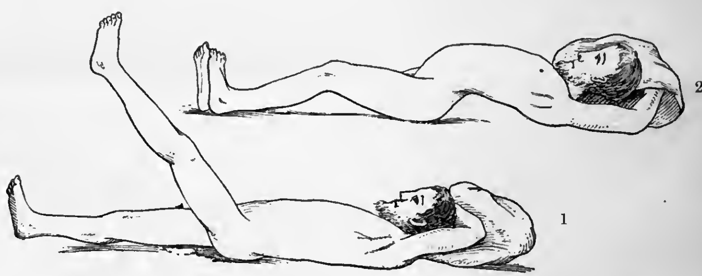

FIG. 137.—Lordosis, resulting from bringing the flexed leg of Hip-Disease parallel to the other (Bradford and Lovett).

the sites of tenderness, the existence of thickening in Scarpa's triangle or near the trochanter, and he also informs himself of the position of the trochanter and its relation to Nélaton's line, and finally feels for any periosteal or bony thickening and for fluctuation.

Attitudes and Measurements.—Abduction with tilting downward of the pelvis and apparent lengthening co-exist. Adduction with elevation of the pelvis on the affected side, and apparent or real shortening, are also associated. We have further to consider practical and real lengthening and shortening. The measurements are made, after marking out the bony points in ink, from the anterior superior spines to the internal malleoli, from the umbilicus to the same spots, from the anterior superior spines to the most prominent point of the tubera ischiorum (for Nélaton's line). We ascertain if wasting of the limb exists by taking the circumference of the thighs at spots at given distances below the anterior superior spines, or above the knees.

Practical (apparent) lengthening is estimated by the differences in distance from the umbilicus to the internal malleoli. So too is practical (apparent) shortening. Real shortening and lengthening are measured by the differences in distance from the anterior superior spines to the internal malleoli. Practical or apparent lengthening depends on abduction of the affected limb with downward tilting of the pelvis on that side. Practical or apparent shortening depends upon adduction and upward tilting of the pelvis. To the patient neither limb appears abducted nor adducted, the two seem parallel. Real shortening depends upon destructive changes in the acetabulum and the head of the femur, or retarded growth of the thigh bone; and it is discovered by marking out Nélaton's line or Bryant's ilio-femoral triangle, or by measuring from the anterior superior spines to the internal malleoli.

It is important to keep a record of the progress of the case. This is indicated in a considerable measure by the increase or decrease of flexion, abduction, and adduction which depend upon muscular spasm and arthritic changes.

Estimation of Adduction and Abduction.—Lovett [1] of Boston has devised a method of arriving at an estimation of these points. We must first ascertain the amount of real and of practical or apparent shortening. The patient's legs should be parallel, and measurements taken from the anterior superior spines to the internal malleoli, which give the amount of real shortening. With the tape stretched from the umbilicus to the internal malleoli practical or apparent shortening is found. According to the amount of deformity the differences between the two kinds of shortening varies. The only other measurement required is the distance between the anterior superior spines. "If the practical shortening is greater than the real shortening the diseased leg is adducted; if less than real shortening, it is abducted." Lovett has constructed a table

[1] *Bost. Med. and Surg. Journ.*, 8th March 1888.

based on mathematical calculation, and a reference to it serves to give the degrees of adduction and of abduction. "We note the difference in inches between real and apparent shortening (given in the vertical line in the following table) and the distance in inches between the anterior superior spines (given in the top line). Then we follow the vertical side line down until the given difference is reached, and the horizontal top line until the width of the pelvis is found. The intersection of these two lines in the table below represents the number of degrees of adduction. As an example take the following: Length from anterior superior spine of right leg 23 in.; of left leg $22\frac{1}{2}$ in.; length (from umbilicus) of right leg 25 in.; of left leg 23 in.; the real shortening is half an inch, and the apparent shortening 2 in. The difference between the real and apparent or practical shortening is $1\frac{1}{2}$ in. The distance between the anterior superior spines is 7 in. Where the horizontal line for $1\frac{1}{2}$ in. intersects the vertical for 7 in., we find the figure 12, and this is the number of degrees of adduction; and as the practical or apparent shortening is greater than the real, there are 12° of adduction of the left leg. If apparent lengthening is present, its amount should be added to the amount of actual shortening."

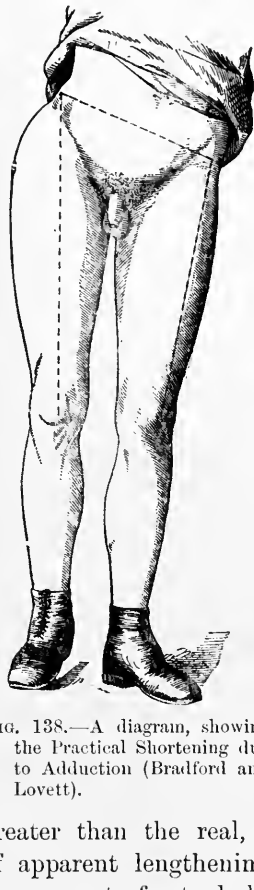

Fig. 138.—A diagram, showing the Practical Shortening due to Adduction (Bradford and Lovett).

[Table

TABLE I.

Difference between the Real and Apparent Shortening.	Distance between the Anterior Superior Spines in Inches.																	
	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

Estimation of Flexion.—"This is effected by a similar method.[1] The patient lies upon a table flat on his back, and the surgeon flexes the diseased leg until the lumbar vertebræ are in full contact with the table. The knee is at the same time held extended.

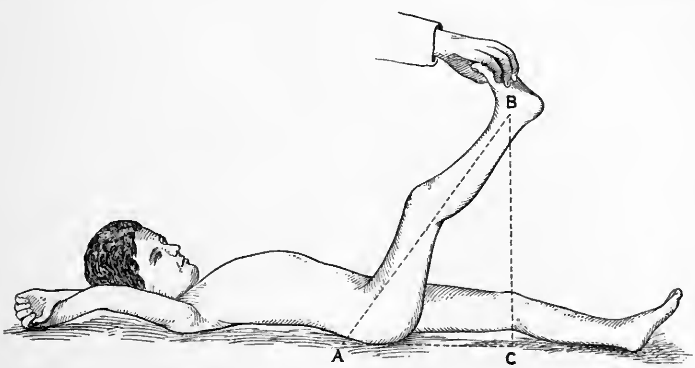

FIG. 139.—Estimation of Flexion (G. L. Kingsley).

The surgeon now measures two feet on the outside of the limb with a tape-measure, one end of which touches the table, so that the tape-measure follows the line of the leg; A B (Fig. 139). From this point B on the limb where the measurement of two feet ends, the distance B C to the table is noted, and the number of inches in

[1] G. L. Kingsley, *Bost. Med. and Surg. Journ.*, 5th July 1888.

the line B C can be read as degrees of flexion of the thigh by consulting the following table. For example, if the distance between the point in the leg and the table is $12\frac{1}{2}$ in., it represents 31° of flexion deformity of the thigh. If the leg is so short that it is not possible to measure 24 in., then 12 in. can be measured. Then ascertain from the distal end of the 12-inch line on the limb the number of inches taken vertically to the surface on which the patient is lying, double the distance, consult the table as before, and the angle of flexion is found."

TABLE II.

To ascertain Degrees of Flexion of the Diseased Hip.

Inches.	Degrees.	Inches.	Degrees.
0·5	1	12·5	31
1·0	2	13·0	33
1·5	3	13·5	34
2·0	4	14·0	36
2·5	6	14·5	37
3·0	7	15·0	39
3·5	9	15·5	40
4·0	10	16·0	42
4·5	11	16·5	43
5·0	12	17·0	45
5·5	14	17·5	47
6·0	15	18·0	48
6·5	16	18·5	50
7·0	17	19·0	52
7·5	19	19·5	54
8·0	20	20·0	56
8·5	21	20·5	58
9·0	22	21·0	60
9·5	24	21·5	63
10·0	25	22·0	67
10·5	27	22·5	70
11·0	28	23·0	75
11·5	29	23·5	80
12·0	30	24·0	90

Method of Recording a Case.—Whitman [1] says that "the record should contain a history of the patient together with an account of the more important symptoms, and of the treatment that may have been employed. A note of the height and weight of the patient should also be taken. The gait and attitude, the character of the distortion, the degree of restriction of movement and its causes, are stated if possible; whether they are due to simple muscular spasm,

[1] Whitman, *Orth. Surg.*, 1901, p. 247.

or to adhesions and contractions. The presence of heat and swelling, abscesses and sinuses, or their absence, are noted. Actual shortening, its causes and distribution, should be stated, and the position of the trochanter particularly observed.

"At the Hospital for the Ruptured and Crippled, New York, a formula is in use, giving the most important points:—

RA – RU – RT – RK – RC – ACE – AGF – ASP – LA – LU – LT – LK – LC.

A = distance from the anterior superior spines to the internal malleoli.

U = distance from the anterior superior spines to the umbilicus.

T, K, and C = circumference of the limb at the thighs, knees, and calves respectively.

AGE = angle of greatest extension.

AGF = angle of greatest flexion.

ASP = distance between the anterior superior spines.

"Thus if the record read:—

RA $18\frac{1}{2}$ – RU 20 – RT 11 – RK $8\frac{3}{4}$ – RC $7\frac{3}{4}$ – AGF 150 – ASP 7 – LA $18\frac{1}{2}$ – LU $21\frac{1}{4}$ – LT $10\frac{1}{4}$ – LK $8\frac{1}{4}$ – LC $7\frac{1}{4}$ – AGF 90

show at a glance that there was no real shortening, that the leg was abducted because there were $1\frac{1}{4}$ inch of apparent lengthening, which, according to Lovett's table, is the equivalent of 10° of abduction. It would show that there is permanent flexion of 30°, and a range of motion between the limit of flexion and extension of 60° as compared with the normal of about 130°."

As the case progresses, careful observations of pain, temperature, appetite, increase or decrease of weight should be made, and, finally, a sharp look out must be kept for fluctuation. It is essential to evacuate an abscess as a rule; rarely it is best to leave it alone.

To sum up the diagnosis of coxitis: It is only by a careful grouping of symptoms and objective signs that a positive conclusion can be arrived at, and in children the objective signs are of more importance than the subjective symptoms.

The valuable signs are:—

1. Limping.
2. Muscular spasm and limitation of movements of joint in any direction.
3. Early atrophy of the muscles.
4. Distorted position of the limb in walking and lying.
5. Swelling.
6. Trochanteric and arthritic thickening.

Differential Diagnosis

In some instances the nature of the case is evident from the first; in others it can only be determined by repeated examination at intervals, and by a careful appreciation of the "symptom-complex."

The following are among the conditions which give rise to doubt, difficulty, and error :—

Local Inflammation and Injuries.—During childhood, inflammation of the glands, often secondary to sores on the feet or to irritation of the genitals, muscular strains, localised rheumatism sometimes described as growing pains, cause temporary limping and some flexion of the thigh. But these signs quickly disappear with appropriate treatment. Again, a fall or a blow may cause congestion of the growing structures in the upper third of the femur, and be followed in most instances by no permanent ill-effect. The exact nature of the trouble can only be satisfactorily ascertained by careful and repeated examination. Children sometimes suffer from traumatic, rheumatic, and infectious synovitis, and it is very difficult to foretell the course which they will take. It is better to be on the safe side and treat the condition for a few weeks as if it were commencing coxitis, rather than to allow the mischief to increase for the want of proper treatment. In infants and young children the possibility of syphilitic epiphysitis must not be forgotten.

Peri-articular Bursitis.—The bursæ usually affected are the psoas and that one between the gluteus maximus and the great trochanter. It is not unusual for a tuberculous infection of the psoas bursæ to be the first sign of coxitis, and the case can only be cleared up by careful watching. Bursitis beneath the gluteus maximus may cause difficulty in diagnosis, particularly if it suppurates, and then it may readily be mistaken for an abscess proceeding from the joint. However, the cardinal signs of hip-disease are wanting in bursitis.

Epiphysitis and Osteitis near the Joint.—Localised osteitis of the ilium, especially after exanthemata, may render the diagnosis obscure. Careful clinical examination and a good skiagram are required. Epiphysitis of the great trochanter, and inflammation of the bony structure of the neck on the distal side of that epiphysis, cause very grave difficulties, yet they imperatively call for early diagnosis and treatment. In either affection the disease may spread to the head and affect the joint. A careful examination under an anæsthetic and the use of the X-rays will be of service. And in any case, when doubts are justifiably entertained, the writer has no hesitation in cutting down on these epiphyses and examining them. On two occasions where this has been done the result has warranted this procedure. In one case, a small but old caseous mass was found in the epiphysial line of the great trochanter; and in the other a similar mass was removed from the shaft side of the epiphysis of the neck. In both cases the joint escaped.[1]

Infantile Paralysis.—The signs of this affection are quite clear a few days after the onset, but at the time of attack severe pain is sometimes present in the joint. It lasts two or three days only. The rarity of tuberculous joint affections in infantile paralytic limbs has been commented on by authors. During the past twenty years the writer has come across only two cases of hip-joint disease in limbs, the sites of infantile paralysis, and they were seen at the Sevenoaks Hospital for Hip Disease.

Acute Infective Arthritis of Infants, whether streptococcic, staphylococcic, or pneumococcic, is characterised by its sudden onset, the age of the patient, generally under one year, the severe general illness, and by the rapid course it very frequently runs, to suppuration and even to pyæmia.

Arthritis Deformans, when it occurs in the young, may give rise to difficulty in diagnosis. However, the polyarticular nature of the affection and an X-ray examination will afford assistance.

Congenital Dislocation of the Hip.—In this case the history, the general freedom of movement and its painlessness, except in rare cases, the elevation of the trochanter above Nélaton's line, and the telescoping of the limb, will serve as sufficient guides; and to them may be added Röntgen-ray photographs.

Coxa Vara.—Again skiagrams are of the greatest value. And the freedom of movement of the joint in all directions, except abduction, the elevation of the trochanter above Nélaton's line from the first, together with actual shortening, are all distinctive points.

Traumatic Separation of the Upper Epiphysis of the Femur, resulting, as pointed out by Whitman, in traumatic coxa vara has given rise to error. Nevertheless, a careful inquiry into the history of the recent injury and skiagrams all help to render the matter clear.

Lumbar Spinal Caries.—When the inflammation has extended

[1] Cf. *Remarks on Para-Articular Tuberculosis*, pp. 50-53.

into the psoas and caused psoitis, limitation of extension at the hip ensues, and other movements are painful. As a rule careful examination of the back will detect rigidity of the muscles or of the articulations, and this is diagnostic. There is, however, an exception to this remark. When the hip itself is the site of great tenderness any attempt at examination will cause the fibres of the erector spinæ to stand out rigidly. So that in some instances it is impossible to express a definite opinion at the first interview, and the case must be kept under careful observation for some time. The diagnosis is often cleared up by pus appearing in the psoas muscle below Poupart's ligament. In any case "never diagnose hip-disease without examining the spine."

Knee-joint Disease.—As pain in the knee is a fairly frequent symptom in hip-joint disease, another axiom may also be given: "Never diagnose knee-joint disease without examining the hip."

Hysterical Affection of the Hip.—Many of the symptoms and signs of coxitis are simulated, and not unsuccessfully, by hysterical girls. The symptoms vary from hour to hour in apparent intensity, and this again is dependent upon the amount of sympathy or curiosity a patient can evoke. In a suspected case of hysterical hip-joint we asked the patient, a young girl, "If she had a friend in the same street suffering from hip-disease." She replied in the affirmative, although our query was a "long shot." When charged with shamming, she admitted the impeachment, and walked away quite naturally. Her friends marvelled greatly at the rapidity of the cure!

Sacro-iliac Disease has been confused with coxitis, and the mistake has been made owing to the want of thorough examination and careful weighing of the signs and symptoms (cf. p. 207).

Sarcoma of the Femur is a most formidable disease. In all cases a skiagram is required, and if confirmatory, the necessity of immediate operation is to be considered.

Abscesses either Intra-abdominal or Parietal making their way downward often cause confusion in their early stages. Thus the surgeon should take care not to be deceived by pus arising in connection with the appendix, the sigmoid flexure of the colon, the kidney, the spine, the pelvic wall, or the sacro-iliac joint. Careful inquiry into the history, thorough palpation of the abdomen, if necessary under an anæsthetic, and digital examination of the rectum, are points not to be neglected.

We repeat, there is no one sign absolutely diagnostic of coxitis.

It is rather the sequence and grouping of signs and symptoms, and in many cases it must be diagnosed by repeated observation and a process of exclusion. With the pelvis gently but firmly held, free, smooth, painless mobility at the hip-joint is the most satisfactory evidence of the absence of coxitis. As to whether the disease is tuberculous or not, we must rely upon the history and course of the affection, and Von Pirquet's reaction.

Prognosis

The question of prognosis may be discussed from two main standpoints, the outlook so far as the integrity, usefulness, and recovery of the joints are concerned, and the effect of hip-joint disease in shortening the patient's life. They are in their turn dependent on the resistance the patient is able to offer to the invasion of tuberculous disease both locally and generally, on the nature of the treatment, and the completeness with which it is carried out. The ideal treatment of the disease is early recognition with enforced and complete rest of the joint for a sufficient period. In average cases this will certainly be at least two years, and more likely three years, and careful protection will be needed for another three years. The more we treat tuberculous joints, the more the fact is forced upon us that very prolonged care is necessary. It is well to be explicit upon this point. Irretrievable harm is caused by premature attempts to get the child up and about. Relapse quickly follows, and is always more severe than the initial attack. Too frequently abscess, extensive caries, and necrosis of bone ensue, and if the child recovers it is with a deformed, shortened limb and permanently enfeebled health. The prognosis of hip-joint disease depends largely upon the care with which the child can be treated from the first, and the persistency of the treatment. Frequent changes of surgical advice are often disastrous, and are due to the impatience of the parents at the slow nature of the cure. The child's social position has a vast deal to do with the successful result of treatment.

The questions which are put in every-day surgical practice by the parents when a child is brought for advice are: Will he recover from the disease, or is it likely to end fatally? If he recovers, will he have a fixed joint or not, and will there be any deformity? And how long will the treatment take?

Danger to Life.—The mortality due to the disease in all classes of cases was formerly reckoned at 30 per cent, but this figure is now admitted to be excessive. A great reduction has been effected by the introduction of antiseptic treatment, as Sir A. Bowlby's[1] figures show. To the end of 1879, of 384 cases treated in the Alexandra Hospital for hip-disease without operation (presumably meaning excision or arthrotomy[2]), 100 died, or 26 per cent. During the twenty-one years from 1885-1906 there were under the charge of Mr. (now Sir A.) Bowlby 900 cases, with a mortality of less than 4 per cent; in itself a striking testimony not only to the soundness of the treatment, but an argument against any extensive operative procedures on the joint. Formerly, the mortality of cases excised was 40 per cent, although this has now been reduced by many surgeons to as low as 15 per cent. The last figure contrasts, however, very unfavourably with the exceedingly low death-rate of 4 per cent in Sir A. Bowlby's series. At the Sevenoaks Hip Hospital the death-rate is only 6 per cent in all cases, thus showing the extremely beneficial effects of treating these cases in country air. Nearly all the cases admitted had been treated at urban hospitals, and were in an unsatisfactory condition on admission to the county hospital. In suppurating cases, especially in towns, the death-rate is very great. Mr. Jacobson recorded a mortality of 73·2 per cent in 63 cases with abscess.[3] Shaffer and Lovett[4] traced 51 cases of cured hip-disease, which had been discharged from the New York Orthopedic Dispensary at least four years previously, and found that 41 had remained cured. Of the remaining 10, 4 had died and 6 had relapsed, although 4 of the latter had apparently recovered after a relapse. The causes of death are general tuberculosis, amyloid disease, exhaustion from persistent suppuration, and chronic septic absorption.

Date at which the Case is brought under Treatment.—This is all-important, and so, too, is effectual and thorough treatment. Unless a case is seen in the early stage and adequately dealt with, recovery, if it takes place, will follow only after more or less

[1] Anthony A. Bowlby, "Nine Hundred Cases of Tuberculous Disease of the Hip," *Brit. Med. Jour.*, 1908, vol. i. p. 1465 *et seq.* This surgeon attributes the 96 per cent of recoveries to the facts that "the main object has always been to treat the child first, and the disease second; and the next reason is antiseptic surgery."

[2] The words in the brackets are the author's.

[3] As to actual figures, Cazin, "Statistique des coxalgies suppurées," *Bull. de la Soc. de Chir.*, November 5, 1876; Shaffer and Lovett, *New York Med. Jour.*, May 21, 1887, may be consulted. Also the figures of Gibney, C. F. Taylor, Hueter and Billroth, are quoted by Bradford and Lovett, *Orth. Surg.* ed. 3, p. 111.

[4] *New York Med. Jour.*, May 21, 1887.

destruction of the bone, either with or without abscess, but generally with suppuration; and there will always be shortening and deformity. Many such cases succumb before adult life is attained. And speaking of the effect of age, the outlook for a very small child is always worse than for one older, as the disease assumes from the first a more severe form.[1]

As to the Usefulness of the Joint and Limb.—In many cases, treated early and under the most favourable conditions, recovery takes place with complete movement of the joint. We can point to many such cases where the diagnosis was indisputable. Such a happy result is more often seen in private than in hospital practice, although it is not unknown in the latter.[2] However, in the majority of favourable cases recovery takes place with a varying degree of loss of movement or with complete ankylosis; and fortunate is the patient if the limb is ankylosed in the straight position.[3] Too often the ankylosed limb is flexed, adducted, and shortened, whilst, sometimes, the resulting deformity is so great as to cripple the child entirely. And it must not be forgotten that even after cure with a partially mobile joint, the mobility sometimes decreases, and deformity ensues unless it is checked.

As to the Duration of Treatment.—This is one of the most important elements in prognosis. A safe rule in giving an opinion is always to exceed in estimating what appears at any given stage the length of treatment required. Two or three years of rigid treatment are none too long for the average case, and careful protection of the joint for another three years.[4] There is no greater error than insufficient treatment, and the surgeon often requires a good deal of moral courage to withstand the supplications of impatient parents. Insufficient treatment or too early movement results in relapse and abscess.

Relapse.—This will certainly occur if the treatment is not persistent, or if the patient injures the joint by a fall or overstrains it by excessive exercise, and if he falls a victim to an acute illness.

[1] Bowlby, *op. sup. cit.* Of 33 children who died of tuberculous coxitis, no less than 24 had been attacked by the disease before they were six years of age.

[2] Five cases of hip-disease treated at the Hip Hospital, Sevenoaks, recovered so well that they served in the South African War (G. Sichel).

[3] At the same institution the results, on discharge from the hospital, were found to be satisfactory in 94 per cent of cases. In no case was a patient discharged with a sinus unhealed, and in all the cases the limb was to some extent useful (G. Sichel).

[4] The length of time spent in the Hospital at Sevenoaks by 50 patients varied from six months to five years, the average being nearly two years. For these and other statistics the author is indebted to his friend, Gerald Sichel, F.R.C.S.

Abscess.—The significance of suppuration depends upon the time and manner of its appearing. If it occurs in a case which has been carefully guarded from the first, or in one which has been for a considerable time under efficient treatment, and especially if its onset be associated with pain, wasting, and deterioration of the health, then the outlook for the patient is bad. A slowly forming painless abscess is not, however, of such serious import, particularly if, when evacuation becomes ultimately necessary, it is carried out in a strictly aseptic manner.

Lovett[1] states that in 574 out-patient cases abscesses appeared in 18·7 per cent. He also adds that in a series of 63 cases occurring in the Boston Children's Hospital the death-rate was 40 per cent.

On general considerations the outlook in a case of coxitis need not be considered very serious, provided that treatment is begun early and is persisted in for a sufficient length of time. On the other hand, ineffectual and half-hearted treatment is a direct cause of relapse, the appearance of abscess, extensive caries and necrosis of the bones, the formation of intractable sinuses, persistent discharge, lardaceous disease, and of death from the last cause or from exhaustion or general tuberculosis.

The Causes of Death.—Dissemination of tubercle is the chief; and the usual form, to an extraordinary extent, is tuberculous meningitis. Next to this in frequency are the effects of prolonged suppuration, viz., amyloid disease and exhaustion.[2]

Treatment

We shall consider this large question from several aspects. The first, and by no means the least important matter, is that of general treatment; then we have to discuss the local aspects of the question, remembering that our line of treatment must necessarily differ in detail according as to whether the patient is the child of well-to-do parents, or is of one of the poorer class coming under our care in hospitals. We would gladly, if possible, apply the ideal treatment to both classes, but those who know the practical difficulties are the most regretful at their powerlessness in the matter.

The ideal line of treatment is early recognition, amply sufficient

[1] *Disease of Hip*, p. 117.

[2] An interesting article on "The Prognosis of Coxitis under Efficient Treatment," by Le Roy W. Hubbard, is found in *Trans. Amer. Orth. Ass.* vol. x. 1897.

recumbency in the best hygienic surroundings, and when a suitable time has elapsed, carefully guarded ambulatory treatment; good food and good nursing; the whole routine to be conducted on the principle that if there is any error to be pardoned it is rather in the directions of excess of care and time, than the reverse. Judicious and careful injections of tuberculin are of distinct value.

General Treatment.—Too little attention is devoted to this in text-books. "The surgeon's first duty is to realise that he is being consulted by a patient who has tuberculosis" (H. P. H. Galloway).[1] This writer also points out that sanatorium methods are as indispensable for the attainment of the best results as in phthisis. The author has frequently [2] urged this aspect of the matter, and has shown by statistics how indefensible and distinctly harmful is the practice of attempting to treat tuberculous hip-disease in the wards of urban hospitals. The whole question of the open-air treatment of surgical and external tuberculosis needs to be placed on a sounder footing than it is at present.[3] It cannot be said that drugs have much influence in these cases, although some good has apparently been obtained by the administration of guaiacol, or preparations of creasote with cod-liver oil. Iron and suitable aperients, plenty of milk, cream, fresh eggs, with a little meat, constitute the main items of drugs and diet. Tuberculin may be injected with the precautions detailed on pp. 35, 36. Marmorek's serum is preferred by some surgeons (p. 42).

Local Treatment.—The principles are rest to the joint and relief of intra-articular pressure. These may be secured in a variety of ways, some more, and others less efficient. The duration of treatment has been adverted to under the heading of prognosis, but it is as well to repeat here that two to three years is seldom too long for rigid treatment, to be followed by another two years of precautionary measures, such as protection of the joint by a Thomas splint, or by one of the traction splints so much used by our American colleagues.

[1] *Trans. Amer. Orth. Ass.* vol. xv. 1902.

[2] A. H. Tubby, *British Med. Journ.*, Feb. 21, 1893, and *Practitioner*, Sept. 1903.

[3] H. P. H. Galloway, *loc. op. cit.*, is convinced that aggravation and relapse of Pott's and hip-joint disease are specially apt to occur during the latter part of the winter, the reason being that the general health and resisting powers have been lowered by months of residence in close, ill-ventilated rooms. (Perhaps this is why ordinary folk feel so run down in early spring.—V. Moxey.) Galloway advocates most strongly the use of tents in a sheltered spot for open-air treatment. They are simple, practical, inexpensive, and efficient. They can be heated in cold weather, and the colder the weather the better is the ventilation in a heated tent. This plan has been tried at the Toronto Orthopædic Hospital, and the surgeons are enthusiastic at the result.

Nevertheless, the main reliance must be placed on rest in the recumbent position. There has been much prejudice against it, because rest in this position and confinement to close rooms and to hospital wards have been so closely associated. The recumbent position can hurt no one, so long as it is carried out in the open air.

We will first consider the treatment, as conducted in this country, of an early case with little or no deformity and without signs of suppuration. And then we will pass on to speak of those cases in which deformity and abscess are present. Lastly, we shall discuss the methods of treatment of early and of well-established cases as practised abroad, more particularly in the United States of America.

Treatment by Recumbency and Extension.—A firm bed is required and the mattress should be of horsehair, supported on fracture-boards, or on woven wire springs which are sufficiently

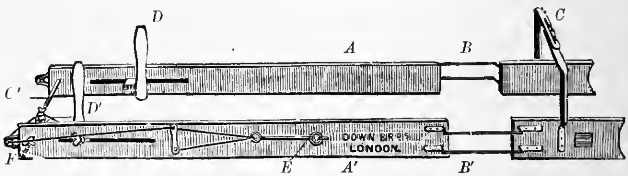

FIG. 140.—Thomas Bryant's Double Splint. It is used, in addition to other purposes in tuberculous coxitis, when the deformity has been nearly, or quite, reduced. A A′, wooden side-pieces, with metal interruptions at BB′, connected by an adaptable metal chest-piece C and a lower bar C′; D, a foot-piece to which the foot of the sound leg is attached; D′, the foot-piece to which the foot of the diseased side is attached; E, an elastic accumulator or spring, exercising traction and extension on foot-piece D′ round a pulley F. The counter-extension is through the pelvis, and the leg of the opposite side to the foot-piece D (Down Bros.' Catalogue).

resistant not to permit the child's buttocks to sink into a hollow in the bed. The forms of splint much in use in this country are Bryant's double splint (Fig. 140) or a double Thomas' (Fig. 149); but the latter has the disadvantage that when the child is lying in bed pressure-sores are likely to form over the prominent bony points posteriorly. A simple method is that of extension by weights and pulleys (Fig. 141), applied in the modified way used by the author (Fig. 142); the child, however, if restless, is likely to disturb the inflamed and irritable joint. For nursing purposes and to secure immobility and extension the Bryant's double splint, provided that deformity is not marked and there is not much flexion, is, in my opinion, the best apparatus. A careful surgeon will, however, be able to secure good results with any of the above arrangements, or by using first one and then the other.

If the Bryant's double splint or weight-extension be used, some means of applying traction to the affected limb must be employed. In many instances we have used an arrangement of an anklet and above-knee-piece made of soft leather, well padded, and connected by straps which can be lengthened at will. Leather is preferable to adhesive strapping, because the latter is likely either to get loose, and to slip, or if put on more firmly, may cause abrasions over bony points. Some of the difficulties in this direction are avoided by placing strips of lint under the strapping over the bony points and the edges of the tibia. Strapping, in which oxide of zinc is combined with the adhesive material, is the least irritating form, but all forms require renewal from time to time.

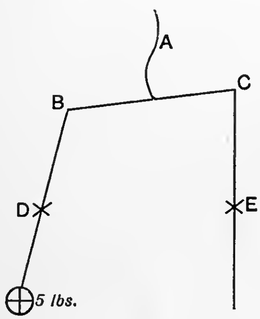

FIG. 141.

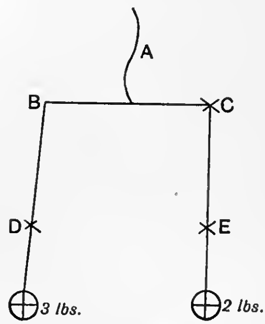

FIG. 142.

The author's Modification of the usual method of applying Weight-extension to a diseased hip-joint. A, lordosed spine; B, C, acetabula; D, E, knee-joints.
In Fig. 141, 5 lbs. weight is applied to the leg on the diseased side, and the pelvis remains tilted with the limb abducted. In Fig. 142, 3 lbs. are applied to the affected side, and 2 lbs. to the sound side, the axis of the pelvis is more nearly transverse, and the abduction is diminished, whilst the distraction at the diseased hip-joint, B, is increased.

As to the tension of the accumulator in the Bryant's splint, this should be estimated by a dynamometer, and it must be remembered that too much extension is as detrimental to the comfort of the patient as too little. A good way is to begin with a weight or pull of two to three pounds for a child under four years of age, and note the effect upon the pain, the position of the limb, and the general health. Roughly, it may be said that over the age of two years, the weight or pull should be one pound more than the age of the child in years, up to the age of five years; but close observation is necessary to determine what is the exact and most beneficial weight in an individual case. The duration of this form of treatment is difficult to estimate in terms of months. It must be kept up, however, for many weeks after all pain has subsided. In a case where the disease has become established, or where pain is severe, complete rest for at least a year or more will be required. The Thomas' hip-splint, although useful in very early and slight cases, is not so readily applicable to the recumbent treatment in confirmed cases. Nevertheless, it is eminently the best appliance to use in the ambulatory stage.

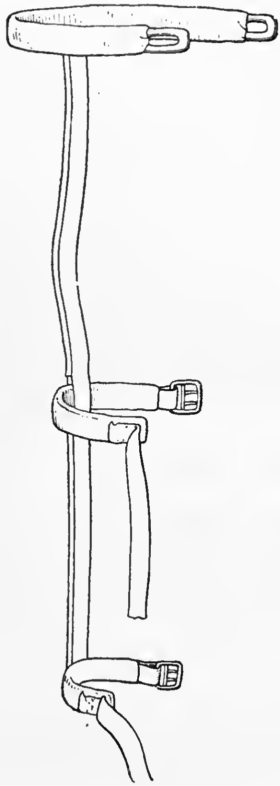

FIG. 143.—The H. O. Thomas' Hip-splint, covered and provided with straps. The lateral pelvic wings for correcting abduction or adduction are not shown.

FIG. 144.—Diagrammatic outline of the H. O. Thomas' Hip-splint, showing the Parallelism of the body- and leg-portions (Ridlon and Jones).

Points of Importance in the Making and Fitting of a Thomas' Splint.—The late H. O. Thomas gave the following description of his splint:—"A flat piece of malleable iron three-quarters of an inch wide and three-sixteenths of an inch thick for children, and an inch wide by a quarter of an inch thick for adults, long enough to extend from the lower angle of the scapula to the middle of the calf, forms the upright. This is fitted to the body of the patient, passing from the lower end of the scapula in a perpendicular line downward over the lumbar region, across the pelvis, slightly external, but close to the posterior spinous processes of the ilium and the prominence of the buttock, along the course of the sciatic nerve, to a point slightly external to the calf of the leg. It must be carefully modelled to this tract. The lumbar portion of the upright must be almost a plane surface, but it must be twisted slightly on its long axis at the junction of the upper and middle third, so that the anterior surface of the lower part may look slightly outward, to correspond with the contour of the back and thigh. A second and double bend is made in the upright at the point where it passes the buttock, so that the thigh part lies on a slightly higher plane than the body part, but *parallel* with it. The upright is then provided with chest-, thigh-, and leg-bands.

"The chest-band is of hoop-iron, one and a half inches in width by an eighth of an inch in thickness. This is bent into an oval to correspond with the shape of the chest, being four inches less than the circumference at this point if the patient is an adult, and of a corresponding size for a child. It is riveted to the upper extremity of the brace, so that a third of its length shall be on the side corresponding to the diseased joint, and two-thirds on the other; and a circular aperture is bored in each extremity.

"The thigh- and leg-bands are of similar material, three-quarters of an inch by an eighth of an inch in size. The thigh-band is in length equal to two-thirds of the circumference, and the band is fastened to the upright at a point one to two inches below the buttock; the calf-band, equal in length to half the circumference of the leg at the calf, is riveted to the lower extremity of the brace. Both the thigh- and leg-bands are attached to the brace at points slightly to the inner side of the centre, so that the outer arm of each band is somewhat longer than the inner. The brace is padded with thin boiler-felt, and is covered smoothly with basil leather.

"In fitting the brace to the patient, the long part of the chest-band should be made to hug the body closely, while the short arm should be somewhat away from it. The anterior surface of the thigh-part of the upright should have a perceptible outward twist, and should be somewhat on the inner side of the popliteal space, so that the splint is prevented from rotating outward and becoming a side splint. The chest-band is closed with a strap and buckle. It is suspended by shoulder-straps or by bandages crossed in front, and the leg between the two lower bands is attached to the brace by means of a flannel bandage. In practice, this bandage may be replaced by a strip of basil leather, passed across the front of the limb down to the upper border of the patella, thence backward and downward to the stem of the splint, and pinned to the covering, so that the resistance to the downward working of the brace is borne by the quadriceps femoris muscle (Whitman). The ordinary shoulder-straps may be replaced by a single bandage looped about the upper part of the stem. This bandage is twisted for a length of about six inches, and then separated; and the ends, being carried over the shoulders, are passed through holes in the opposite ends of the chest-band, where they are knotted; and finally the two ends are tied to one another, thus completing the circumference of the chest-band.

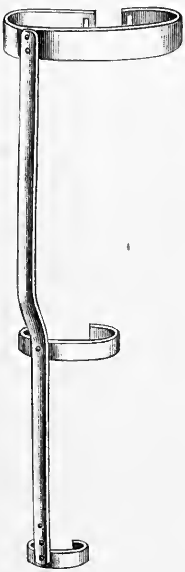

Fig. 145.—The hip-splint in its simplest form, not yet padded or covered (Ridlon).

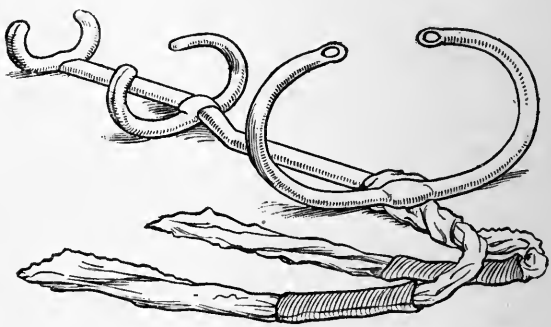

Fig. 146.—The Thomas' hip-splint, covered and fitted with shoulder-straps (Ridlon and Jones).

"The splint is fitted by the surgeon directly to the patient's body as he stands erect. If the limb be already flexed, the foot is raised by means of blocks until the lumbar lordosis is straightened. The brace is then bent so as to fit very nearly to the angle of deformity, and is applied in the usual manner. In cases where the brace has been properly employed, a deep furrow appears in the buttock, directly behind the neck of the femur."

In order to obviate pressure sores there, the skin and subcutaneous tissues are drawn from one side to the other daily, so as to present a new surface for pressure (Fig. 148). In cases where abduction-deformity exists, a lateral wing is added to the splint, which passes round the pelvis on the opposite side to the diseased hip. It is sufficiently long to get a firm grip of the body between the crest of the ilium and the trochanter. In cases of adduction-deformity, the wing—necessarily a much shorter one than the preceding—passes round the pelvis on the side of the diseased joint.

A double Thomas' splint (Fig. 149) is made by joining two single splints. They are united to the chest-band above, and are connected at the lower ends by a cross-bar. Unless the brace is

FIG. 147.—Thomas' Splint applied, with patten and crutches (Whitman, after Ridlon and Jones).

to be used in the reduction of deformity, care is taken that the uprights pass to the outer side, and not directly over the posterior superior spines of the ilium.

To complete the equipment for the use of a single Thomas' splint for ambulatory treatment a boot for the sound side, with a patten sufficiently high to prevent the toes touching the ground, and a pair of crutches, are necessary.

Mistakes in Making and Fitting a Thomas' Splint.—The surgeon should himself superintend the making and fitting

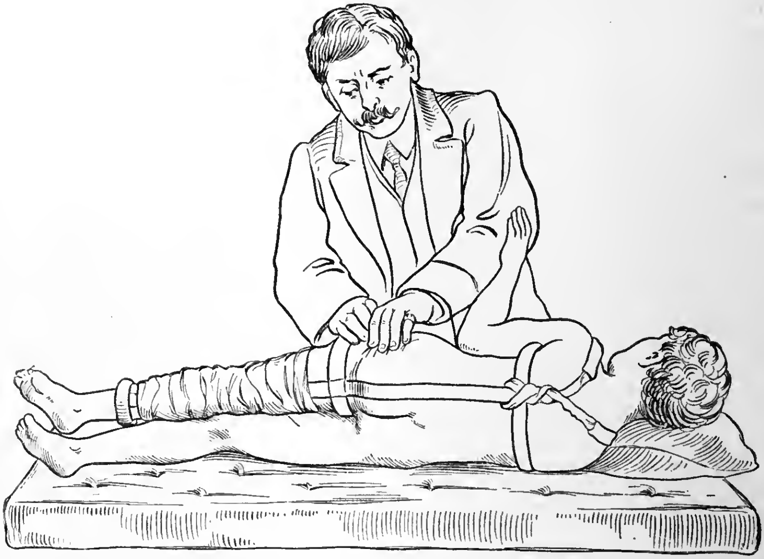

Fig. 148.—Method of changing the line of pressure on the skin from the Thomas' Hip-Splint, by drawing the tissues to one side (Ridlon and Jones).

most carefully, because, if left to instrument makers, very useless patterns are supplied. In fact, it often appears that they have never taken the trouble to read Thomas' original description. One of the common errors is that the splint is made of too light material; so that, if it is held in the air by the lower end, the upper end can be made to wave about. In order to be efficient, the splint must be heavy and strong, and when it is fixed in its proper position it should exercise direct pressure upon the hip-joint. The material is of iron, because it is less elastic than steel, and can be easily twisted by wrenches. The most frequent error of all in shaping a Thomas' splint is to curve it inwards above the buttock part, so that it fits the lordosis; and if it is again bent below the buttock to fit the flexed position of the hip, it is completely useless as a corrective agent.

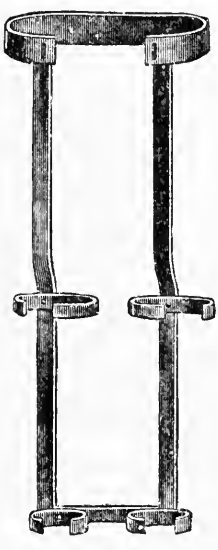

Fig. 149.—The Double Thomas' Hip-Splint (Ridlon and Jones).

The portions of the upright above and below the pelvis should be made quite straight and in *parallel* planes. The idea—a wrong one—which prevails is to bring the splint to the deformity, and not the deformity to the splint. Other errors consist of omitting the outward bends above and below the buttock, and in fixing the splint too much on the outer side of the latter part. So that, in badly fitting splints, after a day or so the upright lies along the outer side of the limb, and not behind it. The surgeon should not be content merely with fitting the splints on once, but should see the patient two or three times afterwards, and be prepared on each occasion to improve his first fitting.

The Reduction of Deformity by Thomas' Splint.—A single, or preferably in children a double splint is applied, and the patient is confined to bed. As the muscular spasm subsides, the splint is straightened slightly by wrenches from time to time at a point opposite the hip-joint, so as to conform to the improved position. This is done until the limb is straightened. In practice, however, if much flexion exists, it is found preferable to reduce the deformity by the inclined plane and the weight-extension method, which will be described presently.

One objection to the Thomas' splint is that it does not effectually check lateral deformity, although the pelvic side-wings are of some use in this direction.

The Thomas' splint is worn for an average period of two and a half years.

Reduction of Flexion and other Deformity.—When the distortion of the limb is due to muscular contraction, it may be entirely reduced by relieving the intra-articular pressure and friction. Undoubtedly the best means of doing so is that devised by Professor Howard Marsh, to whom is due the credit of emphasising one important detail. If a patient with lordosis and flexion is placed in bed with a weight on the leg, the effect of the latter is to increase the pressure within the triangle formed by the psoas, the upper third of the femur, and the lumbar spine and pelvis, so that the head of the bone is rammed against the floor of the acetabulum (see Fig. 150), and the spasm and pain increase rather than diminish. Professor Howard Marsh pointed out that this can be overcome by raising the limb until all the lordosis has disappeared, and therefore all the contraction of the psoas is eliminated. Traction should then be applied by weights *in a line* with the deformed position of the thigh. To bring this about, the limb is raised, and put upon a suitably inclined plane (Figs. 151, 152). At the same time the leg is placed either in abduction or in adduction, until the line joining the anterior superior spines is absolutely at right angles to the median line of the spine. Weights are now applied to the foot and leg to reduce the intra-articular tension, and a second set of weights is fixed to act at right angles to the line of the thigh, above the knee (Fig. 153).

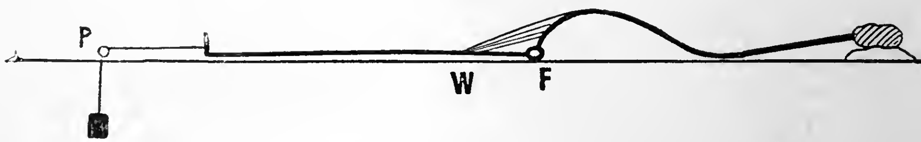

FIG. 150.—Weight-extension, acting as Leverage in Hip-Disease. P, pulley; W, weight; F, fulcrum. Illustrating the ill-effects of leverage on the spine and hip by not applying traction in the line of the deformity of the thigh (Howard Marsh).

If adduction be present, the latter pull from the inside of the limb; if abduction, they pull from the outside. Professor Howard Marsh resists these pulls by the pressure of a cloth band running round the ilium on the sound side if adduction is present, and on the diseased side if abduction is present. In all cases the end of the bed should be raised, so as to obtain counter-extension to the pull

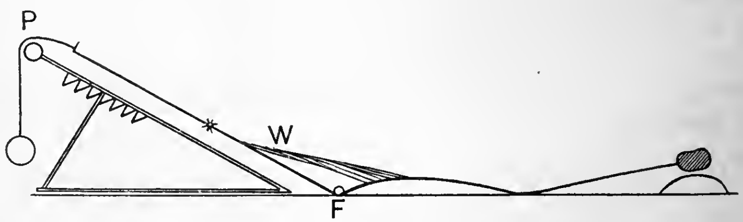

FIG. 151.—The limb is raised on an Adjustable Inclined Plane, until the lumbar spine nearly or entirely touches the bed; in fact, until the limb is raised to an angle of flexion slightly greater than that of the deformity. The results are the disappearance of the ill-effects of leverage, lessening of intra-articular pressure, and relaxation of spasm (adapted, after Howard Marsh).

on the foot. When the limbs are nearly parallel, additional distraction force can be obtained in the joint by putting a weight on the sound side smaller than that on the diseased side (Fig. 142).

After a few days, if trial be made, it will be found that the angle of the inclined plane may be lessened, and the limb brought nearer to the bed, without provoking any spasm or lordosis. The weights are then re-applied in this new position, and this manœuvre is carried out several times until the limb lies parallel with its fellow.

This method of treatment is most valuable in all acute cases, and is one of gradual reduction of the deformity, which is more efficacious than that obtained by the occasional straightening with

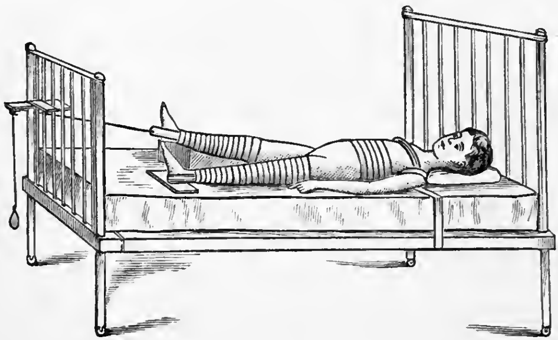

FIG. 152.—Extension in the line of the diseased limb (Howard Marsh).

a Thomas' splint. It also has this advantage that lateral deformity can be corrected as well.

The gradual straightening method is suitable in the acute stage

FIG. 153.—Lateral Traction in Hip-Disease (Bradford and Lovett).

of the disease, and should not be confounded with another method, applied by some surgeons to quiescent cases, where the limb is brought down to the horizontal by frequently repeated manual efforts, or—according to the practice of other surgeons, a course not free from risk—of reducing the deformity at one sitting.

Treatment by plaster of Paris spica bandage is not applicable to the acute stage at all. It is simply protective, and does not carry out the other two important requirements of fixation and traction.

In the United States of America the ordinary gas-pipe bed-frame (see Fig. 72) is much in use. The child's shoulders, pelvis, and affected leg are secured by means of straps. Traction is then applied in the line of the leg by weights, passing over a pulley at the foot of the bed. The foot of the bed should be raised in order to furnish counter-traction.

The length of confinement to bed of acute cases will in most cases be not less than six months, more probably a year or longer.

The methods, we have indicated above, carry out the principles essential in the acute stage, viz. fixation, traction, and protection.

The Treatment of the Subacute Stage.—This should not be entered upon, until all pain and spasm have subsided for at least three months. If the patient's health be suffering from confinement to bed, it may be deemed advisable to allow him to get up a short time daily, with a Thomas' splint on, a patten, and crutches. But, when the patient's health keeps good, it is undoubtedly advisable to keep him recumbent. Some surgeons, notably those in the United States of America, bridge over this period by a discriminating use of traction splints.

Traction Splints. (See Figs. 154 - 158.) — A number of appliances are used to obtain traction, and the principle is essentially the same, namely, perineal resistance, with a pulling force exerted on the limb. Perineal resistance is obtained by means of bands, and the pulling force on the limb is partly its own weight, and is partly effected by the way in which adhesive plaster is applied. Most of the forms, however, are open to grave objections. They do not ensure rest to the joint, the pelvic band being situated too near the hip-joint to control effectually its movements, and therefore some friction must occur. Then, too, the irritation of the perineal bands, if they are tightened sufficiently to ensure complete counter-traction, is such as to cause excoriation and pressure sores. As an improvement the writer ventures to suggest the following modification :—

An inside steel should be added, which should terminate in a thickened pad pressing against the tuber ischii. Such a pad is much more efficient than perineal straps, and, further, the skin over the tuber ischii will bear more pressure than the tender integuments in the perineal fold.

"A traction appliance,[1] as used in the United States, consists of an outside steel upright, reaching from the trochanter to below the foot. At the upper end is a horizontal rigid pelvic girdle, in which the patient is secured by one or two perineal straps. To the lower end of the upright is attached some arrangement for exercising

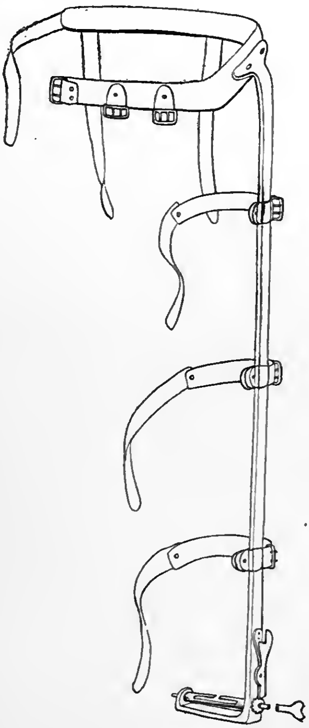

FIG. 154.—Long Traction Hip-Splint (Bradford and Lovett).

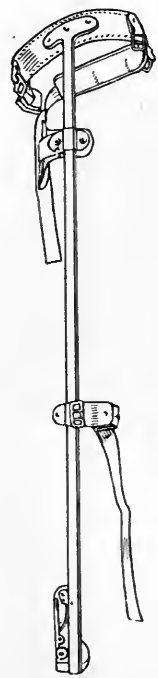

FIG. 155.—Side view of the Long Traction Splint (Bradford and Lovett).

traction on the limb, which is held to the splint by means of webbing attached to adhesive plaster-straps. The adjustment of traction is easily provided for in various ways. One is by means of a sliding rod moving within a tube, the extension of the splint being controlled by means of a key and ratchet, a catch securing the rod when in the proper position. The lower end is furnished with a broadened piece bent so as to pass under the foot, and straps are attached to it which can be secured into buckles, sewn to the

[1] Quoted from Bradford and Lovett, *Orth. Surg.*, 3rd ed., pp. 120-125.

adhesive plaster on the patient's leg. The perineal bands are made of webbing covered with chamois skin, and two perineal bands are better than one. The readiest way to obtain a hold upon the limb

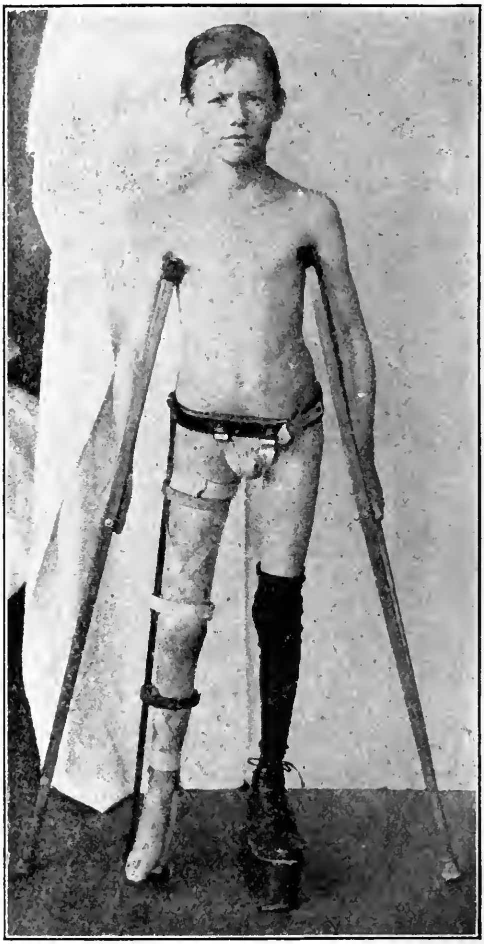

FIG. 156.—Traction Hip-Splint, applied. Patten on the other foot (Bradford and Lovett).

for an extending force is by means of the adhesive plaster, applied as indicated in Figs. 159 - 160. It should be fixed firmly to the thigh above the knee, so as to prevent the excessive pull on the knee-ligaments, with the resulting relaxation and weakness of the joint. The best plaster is that made of adhesive material, combined with oxide of zinc. If the plaster causes irritation, gaiters round the ankle connected with straps above the knee may be substituted.

"The traction splint is applied by placing the child on the back, while a gentle pull is made on the leg by the hand to steady it. The pelvic

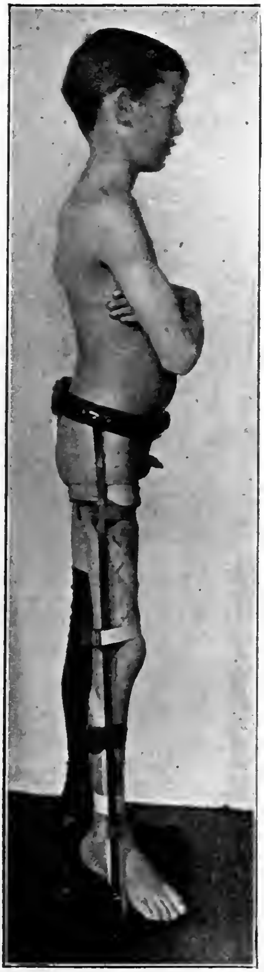

FIG. 157. — Traction Hip-Splint, applied. Side view (Bradford and Lovett).

FIG. 158.—Traction Hip-Splint, applied. Posterior view (Bradford and Lovett).

band is passed around the child, buckled around the waist, and the perineal bands are fastened. The traction straps below the foot are then attached to the ratchet, or whatever extending apparatus is used, and as much traction applied as the child can conveniently stand. The straps around the leg are then fastened. The sound limb is elevated by a raised shoe, and the patient walks with crutches. In cases, in which convalescence has been established, crutches may be dispensed with, and less traction exerted."

The mechanical objections to this arrangement are at once

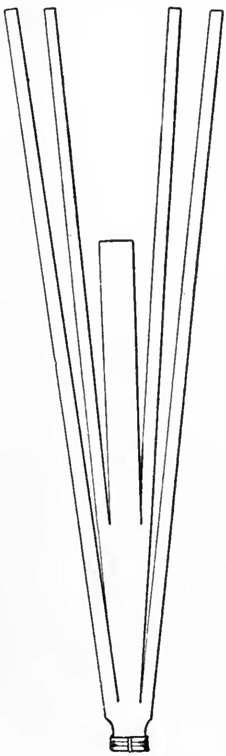

FIG. 159.

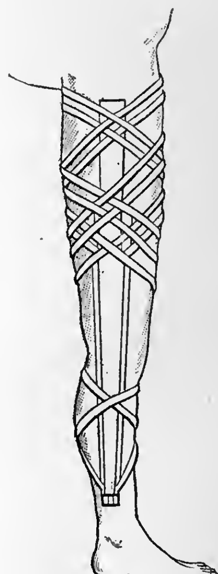

FIG. 160.

C. F. Taylor's method of applying Adhesive Plaster (Whitman).

apparent, and we think that if the case has progressed so far that the Thomas' hip-splint can be dispensed with, the best contrivance is a knee-splint (Figs. 161, 162, 163), with the ring well padded on the inner side, so as to take a bearing on the tuber ischii, and the two uprights united together below by a cross-piece, to which a cord fixed to the plaster loop from the leg can be secured.

Many modifications of the traction-splint have been made with the object of securing greater fixation of the joint in combination with traction, and to allow the patient to move about without rotating the joint. One such splint is that devised by Dr. Dane;[1] yet there is

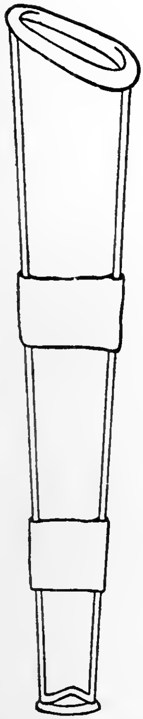

FIG. 161.—H. O. Thomas' Knee-Splint with Ring covered and posterior Leather Attachments (Bradford and Lovett).

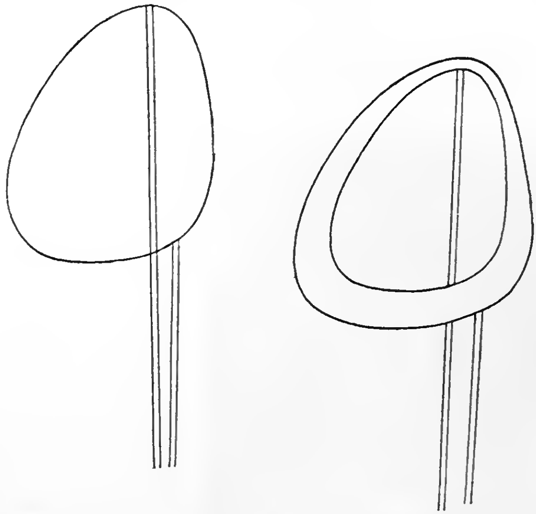

FIG. 162.—Side views of Ring of Thomas' Knee-Splint, uncovered and covered, showing proper shape (Ridlon and Jones).

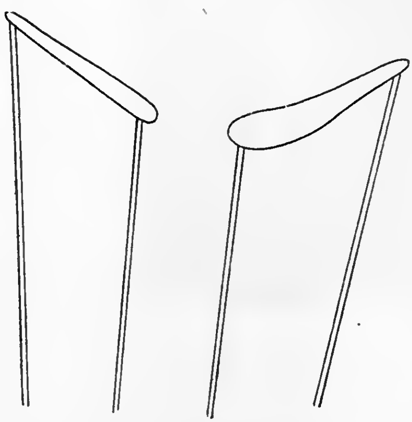

FIG. 163.—View of front and back of Ring of Thomas' Knee-Splint, covered, and showing depression at back for the Tuberosity of the Ischium (Ridlon and Jones).

perhaps no apparatus so efficient for securing fixation (without traction) of the joint, when the patient is moving about, as a plaster of Paris spica, carried well up the body and below the knee.

[1] *Trans. of Amer. Orth. Ass.* vol. x. p. 223, and vol. xiv. p. 74.

Ambulatory Treatment of Hip-Disease.—When all the acute symptoms have subsided for three to six months, and it is deemed advisable to get the patient up, we have a choice of several forms of apparatus. Personally the writer favours the single Thomas' hip-splint, properly applied. It is evident that by this time the necessity for traction has ceased to exist, and the joint requires fixation and protection. After some months of walking on crutches, the height of the patten may be gradually lessened, and the patient is allowed to touch the ground on the affected side with the toes. Eventually the patten is dispensed with, but the crutches are still retained, and the patient is allowed to place both feet on the ground. If there be no signs of irritation in the joint, the Thomas' hip-splint is replaced by a caliper splint, the ends of which are fixed into the sole of the boot, and he now walks with a stick.

FIG. 164.—Results of Suppurative Hip-Disease, treated by Traction for three years, showing the range of movement (Bradford and Lovett).

The time occupied in the mechanical treatment of hip-joint disease will not be less than three years in most cases (Fig. 164), and in many may extend over six or seven. When a Thomas' caliper splint or a traction-splint is used in the last stages of mechanical treatment, a joint may be inserted opposite the knees to enable the patient to progress more comfortably.

Relapses.—The most common causes of relapse are insufficient rest in the recumbent position and improperly applied splints when the patient is allowed to get up. The requirements of the treatment of hip-joint disease are extreme care and the avoidance of any hurry in getting the child about too early. It is better to protect the parts for too long a period rather than too short a one. A relapse is always a disaster. The treatment has to be commenced all over again, and the patient begins his second term of confinement with a worse joint than before. The risk of abscess is also greatly increased.

Whilst recurrence of hip-disease in adult life in a patient, who has suffered from it in childhood, is rare, yet adults with an ankylosed, or partially ankylosed joint, suffer a good deal of discomfort, and sometimes pain, from over-straining of the ligaments and other soft parts, particularly if uncorrected deformity exist. These cases often require rest for a few weeks, or it may be two or three months, and then a fixation splint must be used for a time, and walking gradually resumed.

Treatment of Complications

Abscess.—Generally it may be said that the onset of abscess is in direct ratio to the absence of scrupulous care in giving rest and affording fixation to the joint in the early stages of the disease. The best preventives of abscess are early diagnosis and thorough treatment. Yet in some cases, in which the tuberculous deposit is of a miliary nature, extending widely through the head of the femur and the floor of the acetabulum, pus forms despite careful treatment. More particularly is this so, when the head of the femur is cast off as a sequestrum.

Abscesses occurring in the acute stages of the disease should be carefully distinguished from cold abscesses, which may occur as the result of irritation by sequestra when the active disease has subsided.

The situations in which abscesses are met with have been described on p. 232, and the prognosis of pelvic abscesses is always worse than that of femoral. Further, an abscess which has been allowed to track in several directions is difficult to treat, and is likely to lead to the formation of extensive sinuses, with almost certain infection by streptococci and staphylococci. It therefore follows that when an abscess is detected, it should be dealt with. It is quite true that some become absorbed during recumbency, but if the patient's temperature rises, if night cries re-appear, and if the patient is in pain, it is imperative to evacuate the pus.

Two methods are in general use—aspiration with the introduction of iodoform emulsion or of camphor-thymol, or free incision. Each method has its advocates.

At the Sevenoaks Hospital for Hip Disease the practice has been followed out most successfully of repeated aspirations and injections, and it has not often been necessary to incise abscesses. The success of the practice depends upon early recognition and immediate aspiration.[1]

When an abscess is extensive, especially in the burrowing and pelvic forms, and when it is evident that extensive disease of the upper part of the femur exists, as shown by excessive thickening, or when it is certain that the pelvic wall is extensively involved, thorough evacuation of the abscess cavity is necessary, both for the removal of pus, and with the object of getting away any sequestra that have formed.

The evacuation of an abscess by a free incision is an operation that calls for the most rigid aseptic precautions. The cavity should be freely opened and explored for carious bone or sequestra. They should be removed or gouged out, after which the cavity should be carefully dried and wiped out, using sterilised iodoform emulsion.

It is better not to attempt to scrape away the lining membrane of the abscess wall, as this is protective to the tissues around rather than harmful to the patient, and it must be remembered that tubercle bacilli penetrate to a varying distance into the surrounding tissues, so that they cannot all be removed by scraping; even if this were done efficiently, a fresh surface may be exposed to infection.

The question then is whether to place drainage tubes in the cavities, or to close them at once. If the cavity is a single one, and if the surgeon is satisfied that he has removed the necrotic and carious bone, then we advise that the cavity be closed at once and firm pressure applied. Many such cases heal by primary union, but even in those in which a small amount of fluid collects in a few days after the operation, it can be let out if a probe is inserted between the stitches. It is often clear and non-purulent, and does not re-form.

In those cases in which the pus has tracked extensively, and when infection of the abscess has already occurred on account of its being in contact with viscera, such as the rectum, or where extensive carious inflammation of the pelvic wall exists, it is better to drain with all aseptic precautions; and even then, sinuses will persist afterwards for a considerable time; but as the patient's health

[1] In many cases the employment of tuberculin after aspiration appears to render the semi-solid residue innocuous, and pus-formation ceases after one aspiration. Therefore the two measures should be used in combination.

improves, they often close spontaneously, or after the administration of tuberculin.

Treatment of Sinuses.—In some cases the persistence of a sinus is due to the gradual closing down and partial healing of a large cavity in and around the joint, and there is a varying amount of discharge with the occasional extrusion of minute portions of carious bone. Such sinuses are best left alone, and scraping of their walls does nothing else but harm, for cicatricial tissue has to re-form, and each scraping is accompanied by extension of tubercle into the tissues around the tract. A sinus from which the flow of pus is decreasing from month to month, provided that there is no rise of temperature, and no increase of tenderness, should be left alone. On the other hand, the persistence of discharge may be due to extension of caries, or to the formation of distinct sequestra; and the discharge remains constant, or increases, whilst the patient's health shows signs of deterioration, and he has attacks of pain from time to time. Such cases require careful opening up of the sinuses and a strenuous attempt should be made to remove the affected bone. If the discharge contain septic as well as tuberculous organisms, then antistreptococcic and antistaphylococcic vaccine should be used until the patient's index is satisfactory, and be followed by tuberculin. Large cavities and sinuses often close. Injection of bismuth paste, or, better still and less dangerous, of a mixture of soft and hard paraffin and vaseline, is indicated.[1]

Deformity.—Slight cases of deformity can be corrected by weight-extension applied in the manner indicated on p. 252; or by modifying the shape of a Thomas' splint; or, according to American usage, by the use of the traction splint. The less degrees of deformity are due to muscular contraction, and, as the cause is removed, spasm subsides, and the deformity disappears.

Correction under an Anæsthetic.—This method has come into vogue considerably during the last few years. It may be carried out in one or two ways, either by repeated and gradual attempts, or else at one sitting.

It is quite evident that neither of these methods is applicable in the acute stages, and they should not be attempted. However, when the disease has subsided, and the deformity does not yield to recumbency and traction, the question of reduction under an

[1] *Cf.* Ridlon and Wallace Blanchard, *Amer. Jour. Orth. Surg.* vol. vii. No. 1, Aug. 1909, p. 35. Sir A. Wright has advocated sodium citrate and suction in certain types of sinuses.

anæsthetic may be entertained. Division of the contracted adductor muscles, and of those arising from the anterior superior spine and its neighbourhood, is generally a necessary preliminary; and, personally, the writer favours the gradual reduction in preference to the rapid method. The latter is by no means free from risk. Tuberculous meningitis has followed in several cases, and abscess, with further extension of caries, has also ensued. After each correction the limb should be fixed in a plaster of Paris bandage, and the final position of the limb should be in full extension, with slight abduction.

Osteotomy for Ankylosis.—If the ankylosis is bony no attempts at forcible correction may be made, but osteotomy, either by Gant's or Adams' operation, should be carried out. Gant's operation is an infra-trochanteric osteotomy, after division of the resisting bands of soft tissues; and Adams' operation is a section through the neck of the femur.

By the majority of surgeons Gant's operation is preferred to Adams' operation. The points in favour of Gant's operation are: (1) Inasmuch as the femur is divided below the attachment of the ilio-psoas tendon, the return of the flexion deformity is not so likely to occur as when the bone is divided above the attachment of this muscle; (2) The section is made through healthy bone, and as far as possible from the original site of disease. The disadvantages of the operation are that union is likely to be at an angle, and an ugly prominence appears in the floor of Scarpa's triangle; further, the shortening already existing is increased, but this is of little moment if the leg is straighter.

Adams' operation appears simple, yet those who have had experience know that in many cases the neck of the femur has disappeared almost to a vanishing point, and it is impossible to be sure exactly where the section is being made. Another point against the operation is that the tissues are often so intensely hard in very old-standing cases that there is great difficulty in sawing through the bone; and, we have known at least an hour to be occupied by operators in so doing, particularly when they have attempted to carry out the procedure subcutaneously. Adams' operation, however, has the advantage of avoiding union of fragments at an angle of acute flexion.

The surgeon will decide for himself which procedure suits the individual case under his notice.

Gant's Operation.—For this purpose either a chisel or a saw is used. Personally we prefer the latter, and it should have a rounded end which hooks over the bone (see Fig. 166), in order to obviate the risk of injuring the important vessels in the neighbourhood. Other operators prefer an osteotome, which possesses a temper about half-way between that of a cold chisel and a carpenters' cutting tool, so that its edge will not be turned by the hardness of the bone (Bradford and Lovett). The osteotome is pushed through the sound skin, about an inch to an inch and

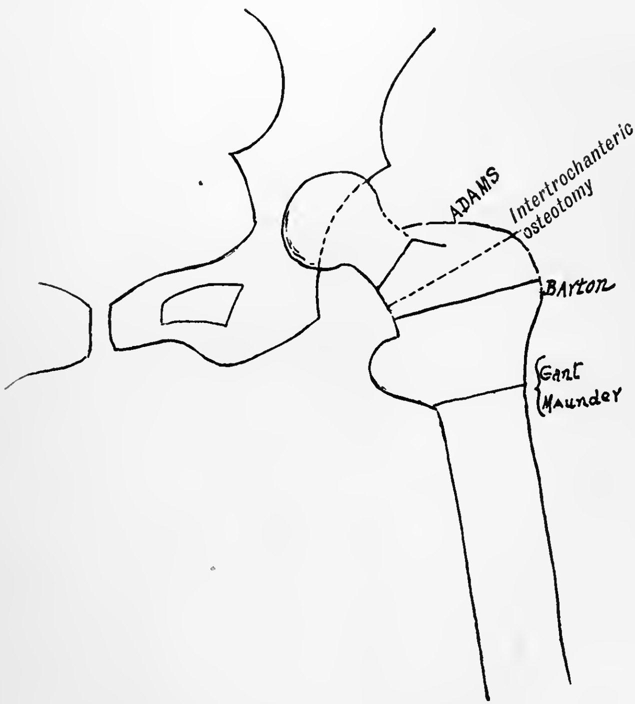

FIG. 165.—Lines of section of the bone, when operating for Ankylosis after Hip-Disease.

a half below the great trochanter. It is at first held with its blade in the long axis of the limb, and when it reaches the bone it is turned at right angles. The osteotome is then driven through the bone until it reaches the inner wall of solid bone. It is then withdrawn, and the remainder of the bone is fractured. It may also be necessary to divide the contracted flexor and adductor tendons before the limb can be brought into good position. The wounds are then sewn up, dressed, and a plaster of Paris spica is applied.

Adams' Operation.—The patient being placed on the opposite side, an osteotomy knife is passed obliquely down to the neck of the femur, entering just above the great trochanter. The skin wound is enlarged somewhat by the heel of the blade, and before withdrawing the knife a flat probe is passed in its tract. Along the probe Adams' keyhole saw is then inserted, and by a rapid sawing movement the neck of the bone is divided. Personally we prefer to make a small vertical incision through the skin and soft tissues, and then to burrow down with the finger to the bone, thus ascertaining at what part the bone can be cut through most advantageously, and subsequently to proceed with the bone-section by the saw. Usually we do an oblique trochanteric osteotomy (Fig. 165).

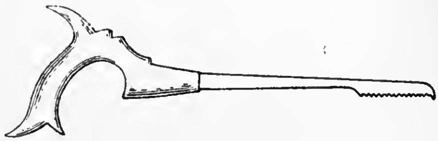

FIG. 166.—Robert Jones' modification of Adams' keyhole saw. Note the shape of the handle and the knob at the point (*Med. Ann.*, 1900).

With the object of overcoming the deformity caused by the adducted and shortened leg of hip-joint disease, Robert Jones has devised the following operation:—He divides the contracted soft tissues through an open incision, and if necessary excises a portion of the contracted adductor muscles, and then performs an oblique intertrochanteric osteotomy, which, if required, is wedge-shaped, the base of the wedge being outwards. It will then be found that the limb can be well abducted, and it should be placed up in this position on a special modification of the double Thomas' splint which he has devised (Fig. 175). In six to eight weeks the parts are healed, and the patient is gradually allowed to get about. The *rationale* of the operation is the ingenious utilisation of the apparent lengthening of the limb, produced by abduction, to counteract the shortening caused by the disease (Figs. 170-174). Of course the pelvis is now tilted downwards, and it will be interesting to note what is the effect upon the spine of this permanent tilting of the pelvis downwards. It certainly cannot be more harmful than the previous tilting of the pelvis upwards.

The formation of a ne-arthrosis near the hip, in order to overcome the disadvantages arising from osseous ankylosis, is discussed on pp. 537, 538.

Excision of the Hip-Joint.—This operation, which was frequently practised ten or fifteen years ago, is now used in very

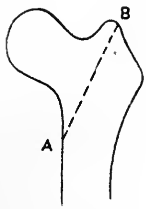

FIG. 167.

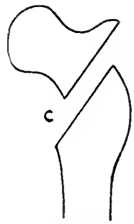

FIG. 168.

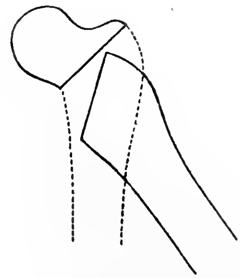

FIG. 169.

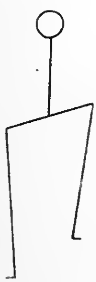

FIG. 170.

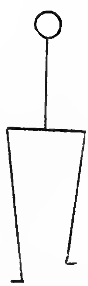

FIG. 171.

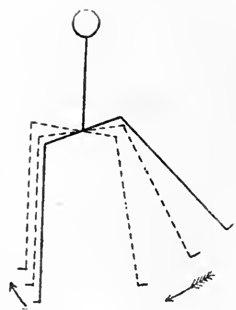

FIG. 172.

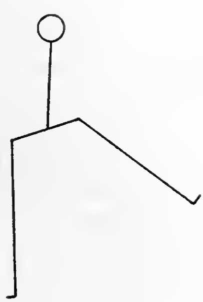

FIG. 173.

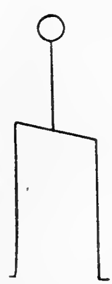

FIG. 174.

To illustrate Robert Jones' Operation designed to overcome the Deformity arising from Adduction and Shortening in Hip-Disease. Figs. 167, 168, 169, Oblique Intertrochanteric Osteotomy and Abduction of the Shaft of the Femur. AB, line of section of bone C. Figs. 170-174 show the mechanics of the method, and Fig. 175, p. 277, the splint and its method of application after the operation (*Med. Ann.*, 1900).

exceptional cases only.[1] The need for it is passing away with early recognition of the disease, its adequate and improved treatment. Briefly, the indications may be stated as follows :—

1. If suppuration occurs, and if, in spite of careful palliative treatment in every direction, the disease is progressing.

2. If there is great pain and persistent loss of health with the suppuration ; and if, after opening the abscess, and careful removal of all the carious bone within reach, the amount of discharge does not subside.

3. If there is extensive necrosis or caries of the head of the femur.

4. If there are signs of extensive destruction of the acetabulum and of the os innominatum.

5. If tuberculous osteomyelitis is extending towards the shaft of the femur.

6. In some poverty-stricken cases, where it appears that efficient treatment by rest cannot be obtained.

Nevertheless, the objects of treatment in hip-joint disease must be to avoid the necessity of even considering the question of excision. The after-results are not so satisfactory as was formerly believed. Two conditions follow : either ankylosis of the parts, or in many cases excessive and flail-like movements.[2] The patient, shortly after excision, may have satisfactory movement with a shortened limb, it is

[1] Sir A. Bowlby, *loc. sup. cit.* p. 146, states that he has never performed this operation in the 900 cases under his care, and his conclusion is that the removal of the head of the femur is never required for the cure of the patient.

[2] Mr. A. R. Thompson, *Guy's Hosp. Rep.* vol. lix., 1905, "A Collection of Cases of Excision of the Hip-Joint," deals with 40 cases. In 2 cases more than 10 years, in 14 cases more than 5 years, in 4 cases more than 3 years, in 12 cases more than 1 year, and in 5 cases less than a year has intervened between the operation and the date of the report. In 6 cases, or 15 per cent, death has occurred since the operation, and 8 other cases are known to have had amputation performed at the hip-joint after excision. So that failure resulted in 14 cases (35 per cent) after excision. In 11 cases, or 27·5 per cent, the result is partial failure, as there are sinuses still present. And in 15 cases, or 37·5 per cent, the results have been successful. Mr. Thompson puts the question of the value of excision very succinctly. He says : "Out of 200 cases in which the hip-joint has been excised, 70 may expect to be the subjects of progressive disease, and of these 30 may be expected to die from continuation and spread of the disease ; 55 will rank as partial failures, in that in these sinuses will persist. In many of these cases, however, sinuses will not interfere with the wage-earning capacity or happiness (*sic*) the individual ; 70 cases may look forward to a complete recovery ; 2 cases, however, amongst these will have a flail joint. The best result, a useful joint with free mobility and without sinuses, falls to the lot of 25 of 200 people, there being in this series of 40 cases only 5 such excellent results." These figures are, in the author's (A. H. T.) opinion, definite reasons for avoiding excision, especially as we know that better results can be obtained by more scientific and less painful means.

true ; but if seen two or three years afterwards the limb is flail-like, practically useless, and much stunted in its growth. Certainly, excision should, if possible, be avoided in children under four years of age, because up to that time an appreciable proportion of the growth of the femur depends upon the integrity of the upper epiphysial lines. After that age, the greater part of the increase in the length of the bone is effected by the lower epiphysis.

Modes of Excision.—Many surgeons nowadays adopt the line of excision advocated by A. E. Barker, which commences just below the anterior superior spine of the ilium, and passes obliquely downwards for about $3\frac{1}{2}$ inches. The line of division between the sartorius and tensor vaginæ femoris is then sought for, and with a blunt dissector the muscles are separated, and the bone is exposed. A few branches of the external circumflex artery require ligature. This incision has the advantage of not dividing any muscles, but it has also the disadvantage of not allowing sufficient space for thorough examination of the diseased area, and especially it does not permit the removal of large pelvic sequestra. In some instances, where the operation has been commenced in this way, we have found it necessary to extend the upper end of the incision backwards, and to separate the attachments of the tensor vaginæ femoris and gluteus minimus from the ilium, thus making a triangular flap of the soft parts. G. A. Wright[1] recommends a nearly vertical incision over the middle of the trochanter, and slightly concave forward. He says : "Where it is proposed to remove a large part of the pelvic wall a flap operation is desirable, and by chiselling off and turning up the great trochanter, with its muscles attached, the power to move the limb subsequently is

FIG. 175.—The affected limb is placed in Abduction on the modified double Thomas' Splint, designed by R. Jones (*Med. Annual*, 1900).

[1] *Dis. of Children*, 5th ed. p. 745.

likely to be greater." In any case the capsule of the joint should be freely opened, and the parts explored with the finger. Separation of the periosteum and soft tissues on the inner side of the bone is effected, until the upper end of the bone is free. Then, passing the finger over the front of the bone, and, if possible, round the inner side, the femur should be sawn through, either by a Gigli's or a keyhole saw. The exact site of section of the bone varies with

FIG. 176.

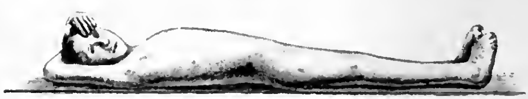

FIG. 177.

FIG. 176.—A patient with Lordosis, Adduction, and Shortening of the right leg, before operation (Robert Jones, *Med. Ann.*, 1900).

FIG. 177.—The same patient as in Fig. 176. After operation, the lordosis has disappeared and the limbs are apparently of the same length (Robert Jones, *Med. Ann.*, 1900).

the extent of disease. In some instances an oblique trochanteric osteotomy suffices; in others it is necessary to cut nearly as far down as the base of the great trochanter. In any case the bone should be sawn *in situ*, and not extruded from the wound; otherwise, a good deal of periosteum is unnecessarily stripped off the bone, with a probability of necrosis resulting.

After removal of the upper end of the femur, the acetabulum is examined and any sequestra removed. If there be a large carious surface it should be gouged or scraped with a Volkmann's spoon, and in many cases it is extremely difficult to remove all the diseased bone. The parts should now be swabbed out either with iodoform emulsion or pure carbolic acid, which is allowed to remain for two or three minutes, being removed by swabbing and douching with absolute alcohol.

Some surgeons have advocated immediate closure of the wound, notably Messrs. Barker and Pollard,[1] but experience shows that this is only applicable to cases of early excision, in which the carious process has not proceeded far and no strong antiseptics have been applied to the cavity, and even then there is some danger of relapse. If the disease is at all extensive, and if sinuses exist, it is not advisable to try for primary union, and therefore a large drainage tube should be passed in. If an intra-pelvic abscess has been present, the acetabulum, if not already perforated, should be gouged through, and the tube passed into the pelvis. A large aseptic dressing should be applied, and the patient placed in a Bryant's double splint. Every effort is to be made to keep the wound aseptic, which may be difficult in children. As soon as possible after the operation, even on the third or fourth day, the patient ought to be brought into the open air and kept continuously out of doors. When the wounds have healed satisfactorily, he should be got up at once. The best form of apparatus then is a double Thomas' splint, with crutches, and a patten on the sound limb.

Some difficulty is experienced with sinuses, which are often slow and intractable. They may be eventually induced to heal by scraping or the cautery, or the regular application of turpentine (G. A. Wright), or an alcoholic solution of carbolic acid to the diseased parts. Eventually the sinuses heal, but any neglect in protecting the part, or undue movement, or irritation of any kind, is followed by their re-opening.

Kocher's Method of Excision of the Hip.—Mr. Stiles, writing in Burghard's *Operative Surgery*, points out that whilst, "at the hip, just as in tuberculous arthritis elsewhere, the chief aim of the operation is the removal of the disease, every endeavour should also be made to obtain as good a functional result as possible. Unfortunately, the anatomy of the hip-joint is such that these two indications can only be imperfectly fulfilled." He, like ourselves, does not advocate the anterior method of Hueter and Barker for advanced cases; and he thinks that Langenbeck's vertical external

[1] *Med. Chir. Trans.*, 1888.

incision is best adapted for those cases in which removal of the trochanter as well as the head and neck of the femur are called for.

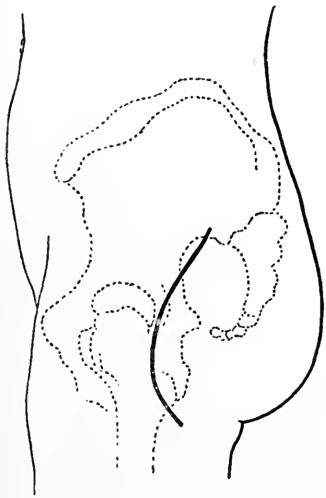

Fig. 178.—Kocher's Incision for Excision of the Hip (Binnie).

Mr. Stiles expresses a very decided preference for Kocher's method in all cases, and supplies the following description :—

"Supposing the right[1] hip to be affected, the patient is placed on the left side in the semi-prone position, with the left thigh extended, and the right flexed and adducted across it. The incision employed by Kocher is an angular modification of Langenbeck's external vertical incision (Fig. 178). The upper half, which is placed obliquely, runs parallel to the fibres of the gluteus maximus, and practically also to the fibres of the gluteus medius. It extends from the posterior superior angle of the great trochanter upwards and backwards towards the posterior superior spine of the ilium. The lower half extends from the posterior superior angle of the great trochanter downwards in the axis of the femur to a short distance below the root of the trochanter. The gluteus maximus is exposed, the fleshy portion above and behind the trochanter is split in the direction of its fibres, while the aponeurotic portion is divided vertically with the knife until the upper part of the glistening tendon of the vastus externus is exposed (Fig. 179). The lower portion of the gluteus medius is defined, its insertion to the trochanter is detached, either with a slip of cartilage from the process in children, or with a layer of bone in adults."

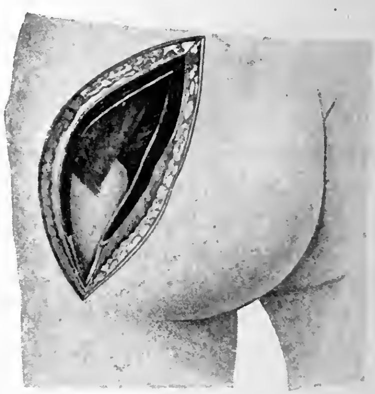

Fig. 179.—To illustrate the method of dealing with the muscles by Kocher in his operation of Excision of the Hip (Binnie).

[1] In Figs. 178, 179 the operation is shown on the left hip, and not on the right as in the text.

The muscles, remaining attached to the great trochanter, are separated, the capsule exposed and opened, and the joint carefully examined. The neck of the bone is then sawn across, particular care being taken that the section includes the calcar, as this is a situation in which a primary osseous focus is often met with. The cut surface is carefully examined, so as to ascertain that the disease has not extended into the trochanter. If it has, the gouge is thoroughly used; or, if the disease is extensive, the trochanter is removed at its base. The acetabulum is then examined, and all diseased parts gouged or chiselled away; and, finally, the tuberculous lining membrane of the capsule is removed.

Mr. Harold Stiles has introduced an important departure in the operation at this point. His object is to attain firm body-bearing ankylosis after the operation. This he effects by "rounding off the upper border of the great trochanter so as to make it fit into the bottom of the acetabulum when the limb is abducted." The wound is closed, the child placed in a modified Hamilton's splint, which has been made into an abduction splint by placing a hinge on the side-piece, corresponding to the affected hip-joint. The degree of abduction is regulated by a movable cross-piece joining the lower ends of the side-pieces. When the wound has healed, *i.e.* after about three weeks, a plaster of Paris case is applied from the level of the nipples to the metatarsus, with the affected limb well abducted, until firm ankylosis is assured. Then, the limb is brought down parallel to its fellow, the pelvis on the affected side being dropped.

The degree of shortening, after excision of the hip, varies considerably, and it naturally depends upon the amount of bone taken away. The later in adolescent life the excision is performed, provided that the upper epiphysis is not entirely removed, the less the shortening will be.

Whilst it should not be forgotten that a timely excision will often avert amputation, yet the trend of surgical experience is that formal and set excisions of the hip-joint are operations which, if possible, should be avoided. They will become fewer in number as the necessity for thorough open-air treatment and the value of vaccines in the early stages are recognised. The ultimate percentage of mortality, after the performance of excision, in cases where mechanical treatment has failed, is nearly 50 per cent, and a considerable number of these deaths (10 per cent) are due to acute miliary tuberculosis, which appears to be directly traceable to the disturbance of the parts caused by operation.

Operation for Removal of the Acetabulum.—Bardenheuer [1] reports his experience of twenty-six cases of resection of the acetabulum for tuberculous and osteomyelitic inflammation of the hip-joint.

The patient is placed on the sound side; an incision is made from the junction of the middle and posterior third of the iliac crest forward, following along the crest, passing over the anterior superior spine, and then inward to the pubic spine, carefully avoiding injury to the vessels.

Both the inside and the outer side of the pelvic bone are exposed, the periosteum being removed as far as possible, using either a raspatory or a knife. This is done on the outer side as far as the joint and the upper border of the sciatic notch, and on the inner side to a corresponding point.

Curved forceps, carrying a Gigli's saw, is then passed from behind on the outer side through the sciatic notch above the pyriformis into the pelvic cavity, and traverses along the inner side of it upwards into the false pelvis. The ilium is then sawn through. The ramus of the pubes is then cleared of soft tissues and sawn with a Gigli's saw, and in the same way the saw separates the tuberosity of the ischium from the remainder of the pelvis, care being necessary to avoid injury to the vessels and nerves. The femur is then divided at the base of the trochanter, and the whole joint removed. It is said to be better that this should be done, when possible, than to remove the head of the femur separately from the acetabulum.

The after-treatment in these cases requires time; in tuberculous cases from six to twelve months. The limb should be placed in a position of slight abduction.

Bardenheuer concludes that the total resection of the acetabulum is not a dangerous operation. Nevertheless, it requires great skill, and with this we agree. "It is indicated in all septic inflammations of the acetabulum, and in tuberculous hip-joint affections, where the acetabulum is so involved that superficial curetting will not be sufficient."

Shortening of the limb is not especially influenced by resection of the acetabulum. The operation is to be used as a life-saving measure when other means fail. We ourselves have not practised this operation, and therefore express no opinion upon it.

Amputation.—This extreme procedure is called for, only when

[1] *Festschrift,* Eröffnung der Akademie für praktische Medizin, Köln.

every other means of treatment—operative and otherwise—have been tried and failed; when the patient is evidently going downhill, owing to the exhaustion caused by the persistent discharge of sinuses; and when lardaceous disease, with albuminuria, is pending, or has set in. Wide and spreading caries of the pelvis, and extension downwards of the disease into the shaft of the femur in the form of tuberculous osteomyelitis, are clear indications for the operation.

In a case, which came under the writer's care, in a man aged twenty-two, who had suffered from hip-disease for seventeen years, the pelvic wall was enormously thickened, and so too was the upper half of the femur. There were no less than twenty-two sinuses, situated all round the parts, which were in a very foul septic condition. It is such extreme cases as this which justify the operation.

The great objections to the operation are the extensive mutilation involved, the intensity of the shock, and the difficulty of fitting a satisfactory artificial limb to the stump. In some cases it appears, when the operation has been done by the Furneaux-Jordan method, that some re-formation of the bone has taken place from the periosteum which has been left behind, but this spindle of bone is not of much service in walking.

Operation.—The important points are to avoid loss of blood and shock. The patient should be carefully prepared, and a rectal injection of warm saline solution (one to two pints, according to the age of the patient) previously given. The limb is raised, and an elastic bandage carefully applied from the toes up to the middle of the thigh. An assistant now compresses the femoral artery against the brim of the pelvis, or the vessel may be controlled by means of a bandage placed over it, which is compressed against the bone by a piece of india-rubber tubing eighteen inches long, and passed round the limb in the following manner:—The mid-point of the tube lies in the perineal fold, it is then carried round the back of the joint, and crosses the great sciatic notch. The two ends are then brought up well above the crest of the ilium, and the tube is so tightly stretched that the circulation in the femoral artery is absolutely controlled. One assistant should be told off entirely for this purpose. In place of the old flap-methods, Furneaux-Jordan devised his well-known operation, which minimises shock and hæmorrhage,[1] gives good drainage, and provides a better stump.

[1] Hæmorrhage in this grave operation may be controlled by using Wyeth's steel-pins and elastic tourniquet (*Ann. of Surg.*, 1897, vol. i. p. 132), or by the forceps-

Mr. Jacobson writes thus (*The Operations of Surgery*, 5th ed. vol. ii. p. 882): "Before commencing the circular amputation I have the limb elevated, an Esmarch bandage applied up to the knee, the thigh emptied of venous blood by firm stroking, and a second Esmarch bandage then applied firmly just below the trochanters, and the lower one removed. The india-rubber band (mentioned above) is also placed, lightly, ready *in situ*. The circular amputation is then performed, and the large vessels secured. The upper bandage is next removed, the region which it occupied re-sterilised, and the india-rubber firmly tightened, while the femur is shelled out or, perhaps, disarticulated if the whole operation is performed in one stage." The femoral and other vessels are then secured, and the state of the acetabulum is observed; if the patient's condition permit, and the state of the parts require it, diseased portions of the bone are gouged away. A tube is inserted into the pelvis, if suppuration in that cavity has existed. The wound is then closed through part of its extent, leaving ample space for drainage.

Sir Henry Howse (Jacobson and Rowlands, *The Operations of Surgery*, 5th ed., vol. ii., p. 884) has removed the limb in two stages, when the patient's vitality has become exhausted by disease. A circular amputation is performed through the lower third of the thigh, and a fortnight later the remainder of the femur is taken away.

A modification[1] of the Furneaux-Jordan operation, which, though not so rapidly performed, undoubtedly saves much loss of blood, is the following:—

After fixing the bandage and tourniquet, a circular amputation is performed at the junction of the lower and middle thirds of the thigh, the bone being sawn through at once at that spot. The femoral and other large vessels are secured on the face of the stump. The patient is then turned on the sound side, and a vertical incision is made, commencing midway between the crest of the ilium and the top of the great trochanter, and carried down at once to the bone, completely dividing the periosteum. The soft tissues and periosteum are rapidly split off the bone, which is then

tourniquet of Lynn-Thomas (*Lancet*, Apr. 23, 1898; *Brit. Med. Journal*, Apr. 20, 1901, and Oct. 1, 1904). Cf. Griffiths, *Brit. Med. Journal*, Dec. 19, 1903, p. 1583.

[1] This operation was performed by W. Brashear in 1806, and recommended and done once by Ollier in 1859. I have seen it performed twice by the late Mr. Davies-Colley, and carried it out once myself.

disarticulated. The state of the acetabulum and pelvis is ascertained, and diseased bone removed as far as possible. As a rule it is not advisable to close the wound in its entire length, but to provide for drainage at its upper part. Rapidity and decision in operating are imperative, and brandy should be given, or hot saline solution infused, if the signs of shock are marked.

In our experience amputation of the hip-joint for tuberculosis has only been necessary in three cases, and two recovered completely and healed well. The third case, a child, died of persistent vomiting a week after the operation, which was probably due to acetonuria.

Double Hip-Disease.—This unhappy condition is met with from time to time.[1] Its treatment is by recumbency, with efficient protection and fixation. If the limbs are flexed and adducted, owing to spasm, they must be brought into the extended position, either by weight traction or by the use of a double Thomas' splint, and then a double Bryant's splint may be fitted. These cases are liable to develop during convalescence the "scissor-leg" deformity, owing to the re-appearance of adduction, therefore convalescence should be extremely prolonged, and recumbency adhered to for a sufficiently long time to establish a cure.

[1] Sir A. Bowlby, *Brit. Med. Journal*, 1908, vol. i. p. 1466, says that of his 900 cases about 40 have had both hips affected.

CHAPTER VII

TUBERCULOUS DISEASE OF THE KNEE, ANKLE, AND JOINTS OF THE FOOT

Tuberculous Disease of the Knee, Ætiology, Pathology, Symptoms, Diagnosis, Prognosis, Treatment, Conservative and Operative—Tuberculous Disease of the Ankle, Symptoms, Course, Diagnosis and Treatment, Conservative and Operative—Tuberculous Disease of the Tarsus and Metatarsus.

TUBERCULOUS DISEASE OF THE KNEE-JOINT

Synonyms—Tumour Albus, Pulpy Disease of the Joint, White Swelling, White Knee, Scrofulous Disease of the Knee.

THE knee-joint, unlike the hip-joint, is not situated deeply or covered with muscles; its outline can be clearly defined on the surface, and it is more easily rendered immobile than the hip. So that early recognition of disease is possible and complete rest is more easily attained. Its articular surfaces are nearly flat and shallow, and, if requisite, can be attacked from all sides except the posterior.

An important factor in the production of the deformity in knee-joint disease is the influence of the hamstring muscles, and by reason of the obliquity of their direction they rotate the leg outwards when the ligaments become softened. The combination of power in the hamstring muscles with oblique direction accounts for the typical backward and outward displacement of the tibia in the established stages of this disease.

ÆTIOLOGY

Tuberculous knee is a disease of childhood, although not to the same extent as is disease of the spine and hip, for adults also suffer from primary tuberculosis of the knee-joint. Yet, in many instances in which this writer has operated upon such joints he has found evidences of old tuberculous epiphysitis, in the shape of caseous foci which have lit up and spread to the synovial membrane. Some such cases had been diagnosed as primary tuberculous synovitis, before operation.

Boys and girls are affected about equally. One of the most common factors in the development of white knee is the incidence of an exanthem, more particularly measles. A child, at about the age of four years, who has suffered from this disease, injures his joint slightly, and soon the typical train of symptoms sets in. In fact, reviewing the question of the onset of tuberculosis, and from our experience in the out-patient department at the Evelina Hospital, we have been induced to regard measles as one of the most potent and dreaded factors in the production of this disease in children.

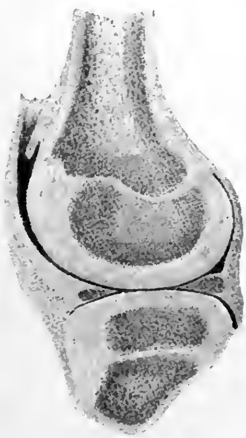

FIG. 180.—Section of Knee-Joint at the age of eight years, showing the Epiphyses of the Femur and Tibia and their relation to the Capsule (Krause). The centre of ossification in the epiphysis of the femur is present at birth. Ossification is completed at about the twentieth year.

The range of motion is from slightly more than complete extension to about 140 degrees. In complete extension the tibia is rotated outward on the femur. In mid-flexion the laxity of the ligaments permits a range of inward and outward rotation of about 25 degrees (Royal Whitman).

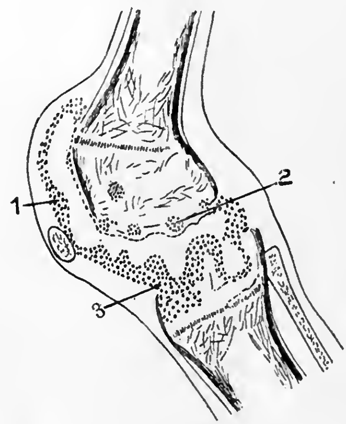

FIG. 181.—Diagrammatic section of a Knee-Joint, to show the Invasion by Tuberculosis of the Synovial Membrane. 1. Supra-patellar Pouch. 2. Tuberculous Focus in Cancellous Tissue of the Lower Epiphysis of the Femur. 3. Tuberculous Material insinuating itself beneath the Articular Cartilages of the Tibia, involving the bone, and replacing the upper end of the tibia by a mass of granulation tissue (Spencer and Gask).

Pathology

The general questions relating to tuberculosis of bones and joints have already been fully discussed, and it is not necessary to insist upon them again. In childhood, certainly, the disease is primarily an epiphysitis, commencing in the head of the tibia or the lower end of the femur, particularly at the attachment of the crucial ligaments (Fig. 181), and rarely in the patella or the head of the fibula; yet cases of extension from the last-named bone to the joint have been known. In the adult, the opinion is held that many cases are primarily synovial, but some surgeons doubt

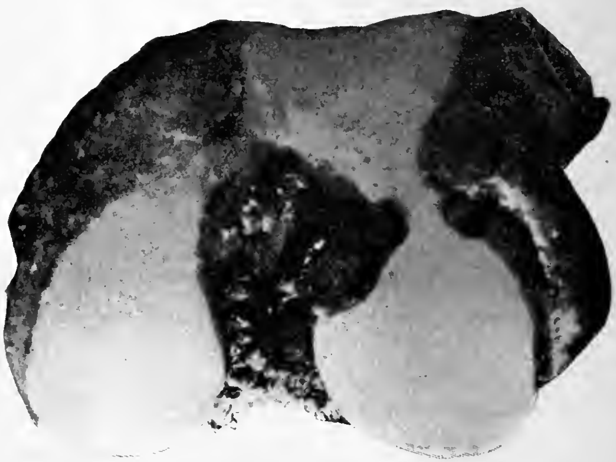

Fig. 182.—Tuberculous Synovial Membrane of the Knee-Joint, spreading over the articular surface of the femur (Alexis Thomson and Miles).

it. They affirm that the existence of a bony lesion cannot be excluded, unless the ends of the bones are carefully examined by cutting thin transverse sections.

We meet with tuberculous arthritis of the knee in three forms: 1. Occasionally as a primary affection of the synovial membrane, as a localised focus. 2. A diffuse tuberculous infiltration of the synovial membrane, proceeding from a more or less localised affection of the bones. 3. Primary tuberculosis of the patella.

When a knee generally affected with tuberculosis is incised, the synovial membrane, particularly on either side of the ligamentum patellæ, is found to be thickened, pink and grey or yellow, and semi-transparent. In places it is soft and semi-gelatinous, and elsewhere, if repair has been taking place, it is tough and fibrous. Caseous foci will also be found in it. Little or no fluid is present, unless pus has formed. The disease advances over the synovial membrane from the primary focus, until it reaches the edges of the cartilages, and then creeps between them and the bone, very much like ivy on a wall. The tuberculous granulations then gradually lift the cartilages from the bone, depriving them at the same time of their nutrition, so that they become yellow and fibrous; and further involvement of the bone takes place. Gradually the process extends until all the structures of the joint are covered with the diseased tissue, and the ligaments, especially the crucial, undergo softening and fibrillation, so that they are gradually relaxed. Then begins backward and outward dislocation. The general cavity of the joint is broken up into loculi by adhesions between the masses of tuberculous synovial tissue. With the gradual deposit of granulations in the subsynovial tissue the capsular and other ligaments appear to become much thickened; and this, amongst other causes, produces the bulbous appearance of the joint. At a cursory glance it appears as if the bones themselves were thickened, but this is very rarely the case, the bulbous appearance being due to the following causes: the atrophy of the muscles above and below the site of disease, the thickening of the periarticular tissues, the hypertrophy of the subsynovial tissue within the capsule, and some distension from fluid. The bones, far from being thickened and hypertrophied, are as a matter of fact undergoing atrophy, and in advanced cases areas of caries, containing caseous material or sequestra of varying sizes, may be found. Such areas sometimes spread, or appear to spread, from the joint towards the epiphyses, but in most cases the process is in the reverse direction. In some instances the epiphysial lines are perforated, and then it is almost certain that the disease has begun as a tuberculous juxta-epiphysitis.

Fig. 183.—Lower end of the femur from an advanced case of Tuberculous Arthritis of the knee-joint. Towards the posterior aspect of the internal condyle there is a wedge-shaped sequestrum, of which the surface, exposed to the joint, is polished like porcelain (Alexis Thomson and Miles, from a specimen in the Anatomical Museum, Edinburgh University).

In occasional instances the disease does not take this course; nor does it, if left untreated, proceed to suppuration, but a quiet process goes on, resulting in gradual loss of movement and ankylosis. In other instances the disease begins by a great pouring out of fluid into the joint cavity, without much thickening of the synovial membrane at first, and these cases are often designated *hydrops articuli.* In yet other cases the early onset of the disease is characterised by symptoms typical of rheumatoid arthritis, and it is rarely possible at first to recognise them as tuberculous. However, if such cases are watched for a long period, the rheumatoid symptoms disappear, and gradually the usual tuberculous appearances come upon the scene. If there be any foundation for the view that rheumatoid arthritis is most frequently seen in patients who have a mixed gouty and tuberculous inheritance, this may explain the difficulty of diagnosis in these occasional cases.

Symptoms

An exanthem or an injury occurring in a child of tuberculous parents, or in one apparently healthy, may be followed by a limp and complaint of pain after any unusual fatigue. With rest the symptoms subside, but re-appear at a later date. Then follows effusion into the synovial membrane, which either does not yield, or becomes very slowly reduced by the usual measures of rest, and possibly of counter-irritation. An early resumption of movement of the part is followed by a similar train of events, and then a thickening of the synovial membrane can be detected. At this time pain is persistent, especially on extension, and the range of movement is limited.

Occasionally the disease begins more acutely with severe pain, rapid swelling of the knee, flexion of the limb, heat, redness, and tenderness. Such a course of events may be due to the sudden invasion of the cavity of the joint by a small quantity of tuberculous material from the bone, or perhaps are examples of the *arthritis de voisinage* of Ollier. In many instances with appropriate treatment this stage subsides, leaving the joint, however, impaired. Rarely, under proper treatment, especially with prolonged rest in the open air, all the symptoms may subside, and the joint recover; but, in other instances, especially among the children of the poor, destruction of the joint is progressive and suppuration follows.

Pain.—The pain is, as a rule, of moderate intensity, although it every now and then increases and becomes acute. It is worse on attempting to move the joint, and any sudden twist or jar causes agony. Night-cries, as a rule, are not so marked as in hip-joint disease. The spot most generally tender on pressure is over the inner surface of the head of the tibia, and in all varieties of knee-joint affections this particular spot is the first where tenderness shows itself, and the last from which it disappears.

Limping.—At first, in walking, the leg is kept slightly flexed, but the power of full extension is retained, although a little painful. Later on, however, this movement is not possible, and the limp becomes quite decided. Lameness is therefore a constant symptom.

Swelling.—In the early stages certain situations should be carefully watched. They are the pouches of synovial membrane on either side of the ligamentum patellæ and the synovial membrane over the inner side of the head of the tibia. In fact, the writer is accustomed to place reliance on palpation over the last-named spot in determining the presence and estimating the degree of thickening of the synovial membrane. It is so superficial here that, by comparison with the opposite side, any thickening can be at once determined by palpation. At first swelling is often limited to either side of the ligamentum patellæ, and gradually extends until the knee is typically bulbous in shape. Less often, however, the supra-patellar pouches are the first to become infected, and the disease creeps downward from the femur to the tibia. It is interesting to note that the supra-patellar pouches appear to be, and on operation are found to be, much more extensive than normal, sometimes nearly twice as large. This is an important point, as in any operation on the joint, for eradication of the disease, these pouches should be freely opened up and dissected out. The same attention should be given to the extension of the synovial membrane into the popliteal notch and over the posterior surface of the head of the tibia.

The skin over the joint has lost its natural hue, is white and anæmic, and often shows the superficial veins to be distended. On palpation, the general feel of the joint is doughy, and when an attempt is made to elicit the patellar click, that bone is felt to be resting on a more or less thick cushion of soft material. In simple serous synovitis the patella can be depressed on to the bones with a distinct click, but such is not the case in tuberculous disease. In advanced cases, and when pus has formed within the joint, the skin becomes reddened at two or three points, gives way, and fistulous tracts are subsequently formed.

Wasting of the Muscles.—Atrophy is present early, and affects both leg and thigh, and is proportionate to the acuteness of the disease. It is not only due to disuse, but to some obscure nervous connection between the nutrition of the joint and the muscles.

Alterations in Length of the Limb.—At times, as the result of irritation of the epiphysis, the limb may be lengthened as much as

FIG. 184.—Advanced Tuberculous Disease of the left knee, with Backward Displacement of the Tibia (Alexis Thomson and Miles).

half an inch in the early stages, but in all late cases some shortening is found.

Local Heat.—From the first the affected joint will be found to be hotter than its fellow. When treatment is proving successful this difference in temperature becomes less noticeable, and finally disappears. If, however, the patient is allowed to go about too soon, it returns, and therefore constitutes a valuable guide to the progress or otherwise of the joint towards recovery.

Muscular Spasm.—As a rule this is present, and the knee is held in the flexed position. As the disease progresses the flexion is complicated by external rotation and by backward displacement of the tibia (Fig. 184).

Deformity.—The characteristic position of the limb is flexion, with subluxation backward of the head of the tibia and external rotation of the leg. The advantage possessed by the flexors over the extensors explains the persistence of flexion, even when the disease has ceased to be active, or has been thoroughly treated. This point has been discussed by Halsted on mechanical principles, and he has shown that the mechanical advantage of the flexors over the extensors does not increase directly with the number of degrees of flexion, but as the fourth power of such a number. Thus, two degrees of flexion give a mechanical advantage of sixteen to the flexors over the extensors. This strong disposition to flexion is one of the greatest hindrances to successful treatment of chronic disease of the knee-joint.

Abscesses and Sinuses.—They are common in knee cases, and require no special mention.

Diagnosis

When the disease is once established the experienced surgeon can determine its nature by external palpation and examination. He should, however, bear in mind such causes of synovitis as hæmophilia, infective and gonorrhœal arthritis, acute rheumatism, arthritis deformans, Charcot's disease, and sarcoma of bone, all of which are accompanied by effusion. In every case an X-ray examination will prove a valuable help, and von Pirquet's reaction is of assistance. Hysterical subjects, especially if they have been with a patient suffering from this form of the disease, often simulate it, and the careful surgeon will be on his guard. An objective sign, such as displacement of the head of the tibia, cannot be simulated. The hysteric lays great stress on subjective symptoms, such as pain, tenderness, and limitation of movement, selecting, however, the most unlikely movements.

Prognosis

In early cases, under favourable hygienic and general conditions, treatment by rest gives excellent results, and occasionally recovery is perfect. It, however, is unusual, and some limitation of movement often remains. In later cases, when suppuration has not taken place, much may be expected from prolonged conservative treatment, so far as the recession of the disease is concerned; although the patient, when he recovers, has a partially stiff and crippled limb.

When the tissues are broken down, the question of local recovery, even after a conservative operation, is more problematical. If the disease has extended into the shaft of the femur or tibia, so as to give rise to tuberculous osteomyelitis, amputation is the only chance of saving life.

In all cases the possibility of the onset of general tuberculosis must not be forgotten.

With regard to the *duration of treatment*, it will probably extend to three years or even longer.

Gibney[1] published statistics of 300 cases. He found that the total deaths were 40, and 26 of them were due directly or indirectly to the disease. With conservative treatment 191 patients retained a movable joint. Of them, in 74 the range of motion was from 45° to normal; and in 41 it was more than 90°. In 51 cases ankylosis was present; in 16 of the 51 the limb was practically straight; and in 35 it was flexed more than 30°. Of the 191 cases in which some movement was retained, the limb could be nearly straightened in 125. Sixteen of the 40 deaths were due to prolonged suppuration, and in 51, still under observation, 26 had been treated for ten years or longer, and were still uncured. If treated by the conservative method and early, the results as to movement and the outlook as to cure of the disease may be described as excellent; but, if the patient does not come under treatment sufficiently soon, the whole sequence of flexion, backward displacement of the tibia, partial ankylosis, and suppuration, is likely to occur. There can be no doubt that, with full and timely conservative treatment, these ill results may be avoided in almost every case.

Treatment

It is not necessary here to advert at any length to the general methods of treatment, save to remark that sea-air is almost a specific for affections of this type in any situation, and vaccination with small

[1] *Amer. Jour. of Med. Sciences*, October 1893.

doses of tuberculin has been tried, but its value is still *sub judice.* Marmorek's serum may prove more useful. Of drugs, cod-liver oil and iron will be found the best.

The *local treatment* may be conveniently discussed under the headings of conservative and operative. In childhood, full trial should be given to expectant methods: whereas, in adults, the question of operative treatment must be entertained at an earlier stage of the disease, owing to the fact that they cannot often spare the time necessary to cure by the expectant method. Again, in a child, it is advisable to abstain if possible from operative interference on the joint and bones, because the mobility of the joint is lost, and removal of a portion of the epiphysis results in progressive shortening and deformity.

In dealing with a tuberculous knee-joint we have to carry out the same principles of conservative treatment as in the hip, namely, fixation and protection, and we may briefly enumerate the means of doing so.

In the first place, the plaster of Paris splint is often of use, and is especially indicated when the limb is straight and deformity has been reduced. It is also of value in children under the age of four, who are too young to use crutches; and, as it cannot be removed easily by the parents of the patients, it is a useful means of avoiding interruptions in treatment. Yet it has certain disadvantages. It is heavy, it may harbour parasites, and is likely to cause pressure sores. It is very doubtful if a plaster of Paris splint can be applied so firmly to the limb as to prevent movement at the knee-joint. It cannot be made to grasp the soft tissues sufficiently to neutralise absolutely all movement of the joint, without causing discomfort from pressure. A common error is to place on the limb a splint which is too short. A plaster of Paris splint for the knee should reach from just below the tuber ischii to within an inch or two above the ankle, and it frequently requires strengthening by strips of malleable iron inserted at the back of the knee, and on both sides.

The *Thomas' Knee-Splint* is widely used, and is probably the best retention-apparatus at our command (Fig. 185). It consists of a perineal ring, two uprights, and a ring at the distal end. The perineal ring is made of iron or steel wire, a quarter of an inch in diameter for a child of ten years, and half an inch for adults. The ring is of an irregular ovoid shape, flattened in front, and turned out at the posterior and inner portion of the thigh, and is fixed obliquely, so that it slopes from without inwards, and from before backwards. The angle made by the ring with the inner upright is one of 135 degrees. The anterior surface of the ring is flat, so as to correspond with the outline of the groin. Its posterior part is convex to accommodate the thickness of the buttock. The ring is tilted downward internally, so as to enable the patient to bear the weight of his body on it through the tuber ischii. In order to gauge the size of the ring, the oblique circumference of the thigh is taken as high up as possible, at an angle of 135° to the long axis of the limb, and an additional inch added for padding. The two lateral uprights should be from three-sixteenths to three-eighths of an inch in thickness, and extend two to three inches below the sole of the foot. The inner bar is attached to the ring further in front than the outer bar. The lower ring serves as a foot-piece, and to it are attached on either side straps by which traction is made on the limb, and the splint is held firmly in place.

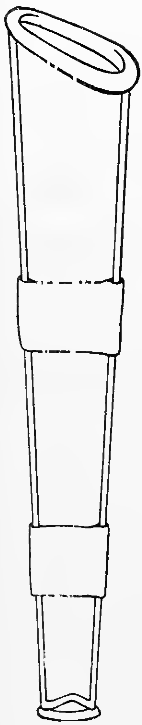

FIG. 185.—H. O. Thomas' Knee-Splint with covered ring and posterior leather attachments (Bradford and Lovett).

When the patient is allowed to walk, a small plate of iron is fitted to the ring to serve as a foot-piece. Two strips of basil leather, about three inches in width, are sewn at one end round one of the side bars, the other end being left free, being of sufficient length to be drawn across to the opposite bar, and, when secured there, they form a support for the back of the limb. One of these straps is to be placed at the back of the knee, or above it if it is too sensitive, and the other just above the ankle. In some instances it is also necessary to add strips of basil leather to support the middle of the thigh and the calf. Traction can be made on the limb by means of straps of adhesive plaster, reaching from the knee to the ankle, and provided at the latter place with buckles, which can be secured to the straps on the foot-piece. The upper ring is padded with boiler felting for a thickness of about half an inch on its outer portion, and up to an inch and a half on its inner posterior portion. The felting is then covered with basil leather or tanned sheep-skin, put on wet, and sewn along the lower and outer border of the ring so that the seam will not chafe the patient. In order to secure the thigh to the splint, a bandage is carried to and fro around the uprights, and fastened in front of the leg, just above the knee, where it passes over a thick pad, generally made of leather, placed in front of the lower end of the thigh. Similarly, a bandage is wound over the limb below the knee, and secured over the anterior pad, placed just below the joint. By means of the pressure of these pads a small amount of deformity can be reduced. The traction on the limb also assists. In some instances, when there is a persistent tendency to deformity, or when the joint is very sensitive, it is well to apply a plaster of Paris bandage to the limb before placing it in the Thomas' splint.

The uses of this splint, therefore, are to serve as means for fixation and support of the limb. It also shields the joint from pressure, the weight of the body being transmitted directly to the ground from the perineal crutch through the ischial tuberosity; and, by traction of the limb to one or the other upright, some lateral deformity may be corrected, while anterior deformity can be kept in check by the pads on the front and back of the limb. The splint is also the means of relieving intra-articular pressure by the traction straps.

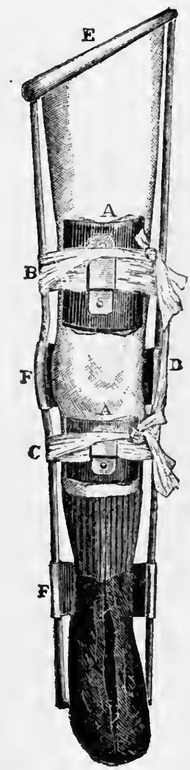

FIG. 186. — H. O. Thomas' Calliper Splint, with pads applied (Ridlon and Jones).

The Thomas' Calliper Splint. — In convalescent cases the lower ring of the knee-splint may be disconnected (Fig. 186), and the lower ends of the uprights turned inwards at a right angle, and inserted into a steel tube, which is passed through the heel of the boot. The bars must be left slightly longer than the limb, so that the patient's heel is elevated nearly an inch from the inside of the shoe in walking, thus avoiding jarring of the limb. When using this splint, a triangular piece should be cut out of the back of the boot, and a loose piece of leather sewn over it. At its base this piece of soft leather should be wider than the heel. The object of the soft leather is to obviate rubbing of the heel.

Extension and Counter-Extension by means of Weights.— These are carried out in the recumbent position, and the limb is fixed in the same way as in hip-disease, except that a leather anklet only is applied; or, if strapping be used, it must not, of course, extend above the knee. An important point is to apply the traction in the line of the deformity.[1] Counter-extension may be made, either by means of a perineal band, or by raising the end of the bed. Lateral deformities can be reduced by the pull of weights suitably applied.

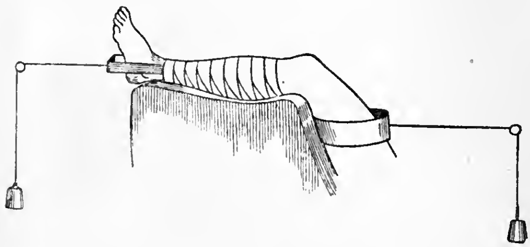

Fig. 187.—Extension and Counter-extension by Weights in disease of the knee-joint (Howard Marsh).

There are many other forms of apparatus in use, but those described above meet all requirements.

Among the accessories to local treatment are injections of iodoform. A sterile emulsion of iodoform in glycerin is made of 10 per cent strength, and about 5 to 10 cc. are injected through a trocar into the joint cavity at intervals of three or four weeks. It is well to be systematic in injecting the joint on each occasion, so that, as far as possible, every part of the joint may be reached in time, and after each injection the joint should be gently massaged to distribute the emulsion. There is no doubt that whilst some cases, particularly those in which the synovial membrane is mainly affected, appear to improve under this treatment, yet iodoform used in this way has not been shown to exert any direct effect upon the tuberculous process itself.

Where the joint is very tender, the actual cautery may be used, somewhat sparingly, with benefit, so far as the pain and irritation are concerned.

Bier's congestive treatment is also of use here, and further, it can be easily applied to the joint. A flannel bandage is firmly wound round the limb to just below the knee-joint. A rubber band, a Martin's or Esmarch's bandage, is then placed above the joint, sufficiently firmly to impede the return of the venous blood. The parts between the bandage rapidly become swollen and congested, but they should not be cold. This form of treatment is applied at first for half an hour to one hour daily, and the time is gradually extended until the treatment is more or less continuous during the

[1] See figure, p. 410, Whitman, *Orth. Surg.* 3rd ed.

day. It is thought that this passive congestion has the effect of assisting the transformation of granulation into fibrous tissue. It certainly causes local auto-inoculation and increases immunity, but it is not suitable in the acute forms of the disease. Bier has also obtained good results even in old-standing cases, with sinuses present. In very painful joints, and in those resistant to bandaging alone, dry-cupping or suction may be used as well.

Having thus briefly described the usual means of treatment, it remains to indicate when they should be employed.

In early acute cases, in which there is considerable pain and some swelling, but no deformity, the patient should be placed in bed, and weight-extension applied, one pound for each year of the child's age up to four, and for an adult six to seven pounds. In a short time the acute symptoms will pass away, and then the Thomas' knee-splint is of service, especially as it permits the patient to get about in the air. If the joint is acutely inflamed, an ice bag for two or three days is very useful at the commencement of treatment; and if pain is persistent, a blister or the actual cautery or dry-cupping is indicated.

When the joint remains sensitive, and it is clear that movement will not be sufficiently restrained by a Thomas' splint applied in the ordinary way, the limb may be fixed in plaster of Paris, as well as in the splint. Whitman[1] states that ichthyol ointment of a strength of about 40 per cent relieves pain and local congestion in some instances.

In cases coming under observation with pain and flexion-deformity, it is our practice to place them in bed and treat them by weight-extension at first. In most instances, where the deformity is due to reflex contraction of muscles, rapid reduction of the displacement follows, and the limb becomes straight. The question of the treatment of persistent deformity must be considered presently.

When, in spite of conservative treatment faithfully carried out, the local condition becomes worse, further treatment is called for, especially if suppuration takes place. Should the child's general condition be good the pus is evacuated, and we may continue to treat the disease on conservative lines; but, if the general condition is deteriorating, then the propriety of a radical operation must be considered.

During the active stage the knee must be kept absolutely at rest. It is difficult to say definitely how long the Thomas' knee-

[1] *Orthopedic Surgery*, 2nd ed. p. 417.

splint or the plaster of Paris should be worn in any individual case. At any rate the next step is to substitute the calliper splint for the knee-splint, and watch carefully for any signs of rotation or flexion of the joint. If all goes well, the calliper splint can be jointed opposite the knee, so as to allow limited movement there; and this can be gradually increased if no symptoms arise; but, no pressure should be allowed on the joint until some months after the subsidence of active symptoms, and then a further period of some months must elapse before any movement of the joint is permitted. The whole duration of treatment is measured by years, and not by months, and if the range of movement is noticed to become less, or flexion deformity appears, in however slight a degree, during convalescence, the protective and fixation forms of treatment must be reverted to at once.

FIG. 188.—Position of deformity in Tuberculous disease of the knee-joint (Bradford and Lovett).

Deformity and its Treatment. — The causes of deformity are many. The flexion position in the early stages of the disease is due to reflex contraction of the hamstring muscles, and the rotation outwards is traceable mainly to the exaggerated action of the biceps. Later on, these muscles undergo structural shortening or contracture, and aggravate the malposition. The appearance of dislocation backwards is an indication that the ligaments, particularly the crucial, have become infected and softened by the invasion of tuberculous granulations. In course of time adhesions make their appearance, and ankylosis, usually fibrous, but very rarely bony, except in the case of the patella, fixes the limb in a more or less deformed position.

When the flexion is merely due to reflex contraction of the muscles, rest in bed and weight-extension suffice to reduce it, or the frequent application of plaster of Paris has the same effect, the limb becoming noticeably straighter at each application. The effect of the Thomas' knee-splint is very much the same.

When the deformity is associated with contracture of muscles, it is, in our opinion, sound practice to divide the shortened tendons, and any bands of the deep fascia over the popliteal space that may be necessary, always by vertical and not by transverse incisions. Then the deformity can be reduced under an anæsthetic, provided that the amount of distortion is not extreme. Some surgeons prefer to do this gradually, and at successive sittings, with intervals of some weeks between, and this is undoubtedly the safer method. Others prefer sudden and complete reduction, although it must not be forgotten that such a procedure is accompanied by grave risks. These are rupture of the popliteal artery, which has occurred, separation of the femoral epiphysis, and fracture of the femur and tibia. The danger of rupturing the popliteal artery is minimised by first forcibly flexing the leg, and then bringing it into the straight line. The general risk is the wide dissemination of tuberculosis, although it must be confessed that experience shows the probability of this is not so great as might be anticipated.

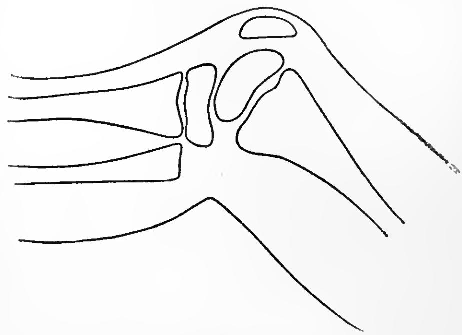

FIG. 189.—Flexion-deformity at the knee-joint, with slight Subluxation of the Tibia (Royal Whitman).

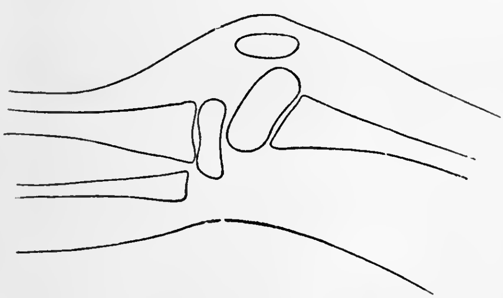

FIG. 190.—After Forcible Correction, showing the Increase of the Posterior Displacement. A drawing from the X-ray photograph of an actual case (Royal Whitman).

When the adhesions are very obstinate, Bradford and Lovett describe a method which does not involve the use of apparatus. The patient is placed upon the floor in the supine position, and the surgeon stands over him, holding the flexed knee with both hands, the fingers meeting in the popliteal space; then, by gradual pressure downward and backward, the knee is extended. When the adhesions are broken down, the leg can be straightened if the patient is turned upon his face, a downward force being applied to the heel, resistance being furnished by a cushion placed under the patient's knee. The great difficulty in all these cases is to overcome subluxation of the head of the tibia, the effect of most of these forcible procedures being merely to crowd the tibia against the femur and to increase the posterior displacement of the former (Figs. 189, 190).

Bradford and Goldthwait have invented a genuclast (Fig. 191), a powerful instrument requiring care in its use, and considerable boldness on the part of the operator. Those who have had much experience in dealing with the ankylosis complicating tuberculous disease of the knee know that frequently the patella is fixed by bone to the front of the femur or the tibia, and it is easy to surmise what the effect upon the parts will be if an attempt is made to break down the ankylosis by means of such a powerful weapon as the genuclast. In such cases a wedge-shaped excision is by far the preferable operation.

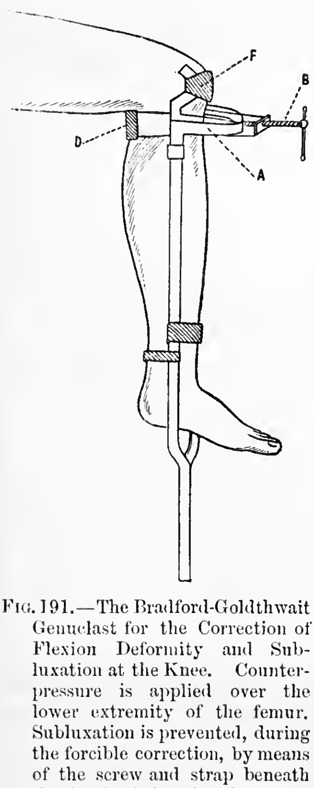

FIG. 191.—The Bradford-Goldthwait Genuclast for the Correction of Flexion Deformity and Subluxation at the Knee. Counterpressure is applied over the lower extremity of the femur. Subluxation is prevented, during the forcible correction, by means of the screw and strap beneath the head of the tibia, by which it is drawn forward (Royal Whitman).

In all instances there is a persistent tendency to recurrence of the deformity, unless stringent precautions, prolonged observation, and a conscientious use of supports are insisted upon.

Abscess.—The treatment of abscess is the same as that of similar tuberculous collections elsewhere; at the knee-joint the pus comes to the surface with great readiness. In some instances, where the disease has originated in the bone, extra-articular collections of pus occur, and make their way to the surface without invading the joint. ("Para-articular Tuberculosis," see pp. 50-53.) Such conditions call for early recognition, and a great aid is a Röntgen-ray photograph. By timely treatment, consisting of scraping and evacuation of pus, the joint may be saved.

RADICAL OPERATIVE TREATMENT

"In all cases of tuberculous arthritis of the knee-joint, when doubt exists as to whether conservative treatment should be tried in the first instance, a skiagram should be taken. If a bone-focus be revealed, operation should be performed without delay. If, on the other hand, there be no bone disease, conservative treatment may be tried in the early stages of the disease, but should no improvement occur within three months, operation should be resorted to; this

FIG. 192.—Tuberculous Disease of the Knee-Joint, which has recovered and retained movement. Subluxation of the tibia is evident (Bradford and Lovett).

applies especially to young children, and in them the disease generally runs a more rapid course than in adolescents and adults."[1] With this opinion of Mr. Stiles we are mainly in accord, but it remains to be seen how far it will require modification, when the uses and values of the new tuberculin are fully understood. We suspect there will be some cases even with bone-foci, as we have seen in the hip, where thorough rest, open air, and tuberculin will arrest the disease and postpone, if not entirely avoid, operation.

Three operations are practised on the knee for this condition: arthrotomy, erasion, and excision.

Arthrotomy.—In some synovial forms, especially that known

[1] Harold Stiles, Burghard's *Operative Surgery*, vol. ii. p. 90.

as hydrops articuli, where there is reason to suspect them to be of tuberculous origin, and if they do not yield to the milder methods of treatment, it is advisable to incise the capsule freely, examine the synovial membrane for any localised area of disease, remove it, and then swab out the joint with pure carbolic acid, which is washed away with absolute alcohol after two or three minutes. Subsequent drainage is not necessary. In some cases arthrotomy reveals a state of affairs which calls for partial erasion. Such an one was the following:—

Case 9.—A woman, aged forty-two years, had swelling and excessive fluctuation with pain in both knee-joints for four years. There was a tuberculous history and her parents had been so affected. On separate occasions each joint was opened and treated in the manner described. The synovial membrane of each knee was found to be studded with firm, fibrous, sessile, warty growths, which were proved by microscopical examination and bacteriological cultivation to be tuberculous. They were cut away, and the joints swabbed out with pure carbolic acid and alcohol. She made an excellent recovery, and obtained 50° of flexion movement in the right and 75° in the left knee. No recurrence had taken place after six years.

Frequently an arthrotomy reveals such a condition of the joint that the surgeon has to decide whether he shall perform an erasion or excision.

Another condition calling for arthrotomy is when there is primary disease in the subsynovial tissue, and it has not yet perforated into the joint. An instance of the value of arthrotomy, for a time it is true, occurred in a case in the writer's practice at the Westminster Hospital.

Case 10.—A boy, aged four years, was seen in the out-patient department with a localised swelling of the size of a pigeon's egg on the inner side of the patella and over the head of the tibia. The joint was free, the synovial membrane not generally thickened, there was no fluid, and the movements, though limited, were not painful. A localised subsynovial (para-articular) tuberculous area was diagnosed. An incision was made over it, and we found that it could be completely removed without opening the joint. For four years the child remained free from trouble, running about in the usual way, and then he fell and knocked the knee, and subacute symptoms set in. These progressed in spite of treatment, and an arthrectomy, almost amounting to an excision, was performed with satisfactory results.

Erasion or Arthrectomy.—It is better to use the word erasion, because it is more precise and indicates more fully the scope of the operation as carried out by its originator and ardent advocate, Mr. G. A. Wright, of Manchester.[1]

The operation consists of systematic removal of all diseased material from the joint. If the bones are diseased the affected areas are gouged out, and "the more advanced the disease the less typical will be the erasion"[2]

Mr. Wright advocates erasion in children in preference to excision on the grounds that there is less interference with the growth of the limb, and mobility may be preserved. With the former we fully agree, of the latter we shall speak presently.

As to interference with growth after erasion, Kœnig[3] gives details of the shortening in forty-eight cases in which the operation had been performed before the tenth year, and where the limbs were straight.

Number of Cases.	Years elapsed since Operation.	Average Shortening in Centimetres.
6	2	1
5	3	1·6
4	4	1
3	5	2
19	6 to 7	2
11	8 to 13	2·5

It will be seen that shortening is present, and is not excessive. As to mobility after erasion, it is quite clear that it is not to be expected when the erasion is complete, and especially if it is found necessary to remove much of the capsule or to take away the crucial ligaments. Mobility can only be anticipated when the operation partakes more of an arthrotomy than erasion. If the disease is at all advanced in children, then we must abandon all hope of mobility and secure a firm limb, with ankylosis in the straight position. The chief difficulty in after-treatment is to avoid the flexion-deformity, for the ankylosis is by fibrous tissue, unless the bones have been freely attacked. In any event a strong, straight limb is preferable to a partly movable and probably deformed one.

In our own practice, in private cases, we have had little or no

[1] *Lancet*, 1881, vol. ii. p. 992; *Med. Chron.*, July 1885; (with Mr. Haslam), *Brit. Med. Journ.* vol. ii., 1903, p. 888.

[2] Jacobson and Rowlands, *The Operations of Surgery*, 5th ed. vol. ii. p. 948.

[3] *Deutsch. Zeitschr. f. Chir.* Band li. Hefte 3 and 4.

difficulty in obviating the flexion-deformity. In hospital cases there are many hindrances to obtaining a firm, straight limb. The parents do not bring the children up sufficiently often to renew the plaster of Paris or to attend to the fitting of other kinds of support. In fact, after a year or two they may on their own account dispense with them altogether, with the result that distressing deformities arise and necessitate rectification, often involving removal of bone, so that ultimately the joint is practically excised.

Erasion is found to be most suitable in those cases "where the disease is limited, or almost limited, to the synovial membrane, with little, if any, caseation; where the cartilages and bones are almost intact; where there are no abscesses or sinuses; where there is no evidence of other tuberculous disease" (Jacobson and Rowlands). In effect the operation is limited to young children, and in others it is suitable for localised tuberculosis of the synovial membrane.

Its great disadvantage is that it is difficult to remove the disease from every part of the joint, particularly at the posterior surface of the tibia. And, unless this is done, abscesses and sinuses form in the popliteal space, and the patient is worse off than before. To be quite sure that this region is exposed, the crucial ligaments are sacrificed, and subsequent displacement of the tibia is difficult to prevent. Moreover, there is a risk of minute apertures leading to diseased areas being overlooked; and, according to Mr. Jacobson,[1] if excision is required later, the parts about the posterior ligaments are difficult to identify.

The Operation of Erasion.—The knee is opened by a semilunar incision passing below the patella. The skin is reflected, the ligamentum patellæ is divided, and the proximal end is turned upward with the capsule. From the horizontal incision a vertical incision should be made upwards on the inner side of the suprapatellar region, so as to open the whole length of the synovial pouches. Then, with a scalpel or scissors every particle of tuberculous tissue is cut away. The infiltrated capsule and the semilunar cartilages are removed, and the articular cartilage scraped quite clean. If any sinuses are found leading into the bone, thorough gouging out is necessary. The chief difficulty is to clear the back part of the joint and the popliteal notch. For this purpose one or both crucial ligaments must be divided, the knee thoroughly flexed, and the head of the tibia drawn forwards. Drainage may

[1] *Op. sup. cit.* vol. ii. p. 949.

be used, but as a rule it is better to avoid it. If tubes are put in, they should be placed toward the back of the joint. Generally, the author does not drain his cases; he seeks to obtain primary union.

The after-treatment consists of putting the limb on an interrupted wooden back-splint, with a foot-piece and two side-pieces, until healing is complete, and then either in a Thomas' splint or a sufficiently long plaster of Paris case for three months. A leather splint, reaching from the groin to the ankle, is worn for several years afterwards, and the child is seen at intervals, to make sure that the splint is efficient and no flexion deformity is beginning.

Excision.—The operation is called for when diffuse tuberculous disease of the synovial membrane and disease in the bones is present. Pathological examinations have shown that, if the synovial affection is at all extensive, the bones rarely escape.

Much has been written on excision of the knee-joint, and the two most comprehensive accounts are, one by Mr. (now Sir) Henry Howse, with an analysis of 130 cases by Dr. G. Newton Pitt,[1] an admirable summary of an unrivalled experience of this operation; and the other is by my friend and former teacher, Mr. W. H. A. Jacobson, in *The Operations of Surgery.* To these writings we refer our readers for fuller information than our space permits.

Indications.—These may be inferred from what we have already said on erasion, but we summarise Sir Henry Howse's views. The operation should be performed: (1) In all cases of advanced disease, whether suppurating or not; (2) When backward displacement of the tibia is present; (3) When the disease has begun in the bone; (4) If extensive suppuration in the joint is present; (5) In all cases of widespread synovial disease. And to these we would add (6) *cæteris paribus,* in children over 12 years of age.

As a preliminary to the operation, as much of the flexion deformity as possible should be rectified. By doing so, the operation is rendered easier, and the direction of the saw-cuts can be more accurately estimated. Moreover, by gradual preliminary straightening, using weight-extension, and, if need be, manual force carefully and intermittently applied, all risk of sudden stretching of the popliteal vessels and nerves at the time of the excision is avoided; and, further, with a straightened limb the posterior part of the joint becomes more accessible, and less bone is sacrificed to effect this.

[1] *Guy's Hospital Reports,* vol. xlix., 1891, pp. 169-274.

The Operation.—Surgeons are now agreed that it is undesirable to use an Esmarch's bandage, for, as the vessels are divided all the bleeding joints are caught up and tied.

Many forms of incision have been practised. Our preference is for the semi-lunar passing across the joint from condyle to condyle just below the patella, with a vertical extension upwards on the inner side of the patella, so as to expose fully the supra-patellar pouches. Some surgeons prefer to remove the patella, others to retain it. However, bearing in mind Mr. Stiles' opinion that primary tuberculosis of that bone is not so rare, we remove it, unless a vertical section through it shows it to be free from disease, when it may be retained for a special purpose. The flap is reflected, and every particle of disease in the soft parts is cut away, the ligaments and cartilages being sacrificed in the process, and particular attention paid to the posterior aspect of the tibia, although this is better dealt with after the bones have been sawn. The neighbouring tendon sheaths are carefully examined and sinuses tracked. With the knee acutely flexed, the articular surface of the femur is sawn away: the limit of safety, so far as the epiphysial line is concerned, being one to two lines above the level of the intercondyloid notch. If disease has extended through the growing line a gouge is carefully used. The line of section through the femur is at right angles to the axis of the limb, and not to that of the femur. Not more than a thin slice, about one-quarter of an inch in thickness, is removed from the tibia. All hæmorrhage having been arrested, and having made sure that the limb is straight when the bony surfaces are brought together, we consider whether we shall trust to the accurate fit of the bones to ensure ankylosis, or if we shall re-inforce the junction. The plan [1] I have adopted is to divide the patella transversely in the first incision, and at the last stage saw off the posterior surface of the divided patella and the anterior surfaces of the femur and tibia, and then to wire the four portions of bone together. I have found this plan very effectual, and since its adoption have been seldom troubled afterwards by flexion-deformity. Yet, I have not failed to insist strenuously upon the use of a leather splint for some years subsequently.

The late Mr. Morrant Barker devised the well-known pins, which I have used, but not found of much service. They soon become loose, and they have to be withdrawn either for this reason or because they irritate the skin. Other surgeons have used ivory pegs or

[1] *British Med. Jour.* vol. ii., 1903, p. 893.

nails. The latter, if securely and snugly buried, are very useful in securing firm co-aptation of the bones. The wound is now closed, except for two small apertures on either side to allow plasma to ooze away, and it is undesirable to insert drainage tubes, unless suppuration has occurred in the joint previously to the operation. After dressing the part, a splint is applied; and in our opinion Sir Henry Howse's splint, designed for this purpose, is incomparably the best. Its construction and application are fully given in his original article.[1] The limb is then swung in a modified Salter's cradle. Simpler, but not so efficient, are the Thomas' knee splint, the wooden back and two side splints, or a Desault's splint, with a thigh-piece added to steady the posterior aspect of the limb.

After-Treatment.—When the wound is soundly healed and ankylosis is firm, generally in about three months, plaster of Paris bandages are applied from the groin to the ankle for another three months, and then a leather splint is fitted and worn for two to three years.

Results of Excision.—To prove successful, the operation should cure the patient of the local disease, be followed by the healing of sinuses, whilst the limb should be straight and firm, and remain so. In the monograph by Sir Henry Howse, frequently referred to, the results of 130 operations are tabulated by Dr. Newton Pitt, and we can see how the operation was gradually perfected by Sir Henry Howse, if we study the statistics of the first 20 cases as compared with the last 20 cases:—

Of the first 20 cases—	Of the last 20 cases—
7 were entirely satisfactory.	11 were entirely satisfactory.
3 were satisfactory.	4 were satisfactory on discharge, but after-history is unknown.
3 were flexed.	2 were very slightly flexed.
5 were amputated.	2 were amputated.
2 died.	1 died.

Sir Henry Howse found that, taking 130 cases, the total mortality from all causes within six months after excision was 6·2 per cent, and for cases under 20 years of age 2·3 per cent. Of the survivors, more than one-half have been found several years later to have most excellent serviceable limbs.

Amputation.—Under improved conservative treatment fewer cases than formerly require arthrectomy or excision, and still more

[1] *Guy's Hosp. Rep.* vol. xlix. pp. 208-10; also *The Operations of Surgery*, Jacobson and Rowlands, 5th ed., vol. ii. p. 960.

rarely is amputation called for. If arthrectomy or excision has failed, and the limb is riddled with sinuses, discharging persistently, and the patient is steadily going down hill, then amputation is indicated. It is imperative in those cases in which tuberculous osteomyelitis is extending upwards or downwards along the shafts of the bones. Again, if disease is so extensive in early childhood as to cause serious interference with the epiphysial line, amputation is the best method, for the subsequent shortening after excision is great and leaves a limb of little practical use later.

Operative Treatment of the Flexion Deformity.—In young subjects, with angular deformity of the knee after the operation, linear osteotomy of the femur is preferable to the removal of a wedge-shaped piece of bone, and answers quite well in straightening the limb. Indeed, the final results are better, because none of the growing tissue is removed. In adolescents and adults wedge-shaped excision is necessary, particularly when the ankylosis is bony, and the patella is adherent. A few hints may be given as to the method of removing the wedge.

Fig. 193.—Method of removal of a wedge-shaped portion of bone for Ankylosis succeeding Tuberculous Knee (Robert Jones, *Med. Annual*, 1900). The apex of the wedge does not extend to the posterior margin of the bones.

It is not advisable to carry the saw or chisel as far back as the posterior ligaments of the joint, because of the danger of wounding the popliteal artery, and the difficulty of bringing the limb quite straight with the bones properly apposed. If the apex of the wedge be carried as far back as the ligaments of the joint, an awkward projection at the posterior parts of the ends of the bones is left, which renders accurate reposition difficult. The best way is to plan the wedge so that its apex shall meet in the joint line about half an inch in front of the posterior bony surfaces (Fig. 193). The wedge is then removed, and the bridge of bone is broken down by firm flexion of the knee. The remaining bone is carefully chiselled away, and the surfaces accurately co-apted. In this way, not only is good apposition obtained, but all risk to the popliteal artery, either by wounding or stretching it, is avoided. Genu valgum may be corrected by a linear osteotomy.

General Conclusions.—In childhood, early and thorough conservative treatment holds out the prospect of complete recovery, and in some cases of a useful range of movement. The duration of treatment is from two to five years. Deformity can and must be prevented by adequate supervision. In such cases no radical operation will be necessary. The mortality in childhood from all causes should be less than 5 per cent. In the adult, operative treatment should be resorted to earlier than in childhood, because of the economy of time. The main objects of treatment, whether conservative or operative, should be the removal of the disease, with a firm and stable limb; and stability should not be sacrificed to any attempt to retain movement.

TUBERCULOUS DISEASE OF THE ANKLE AND JOINTS AND BONES OF THE FOOT

The Ankle.—Disease may commence in the articular ends of the tibia and fibula, or in the astragalus. When it commences in the lower end of the fibula it may remain for a time extra-articular,

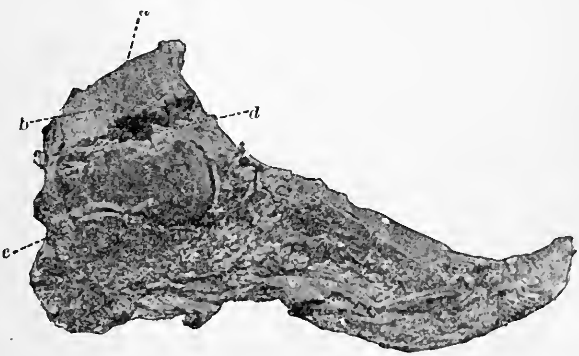

FIG. 194.—Tuberculous Ankle-Joint. *a*, Lower end of tibia; *b*, tuberculous cavity in lower end of tibia; *c*, tuberculous disease of the os calcis, *d*, of astragalus (Bradford and Lovett).

as the epiphysial line is well outside the limits of the ankle-joint. The disease sometimes commences in the os calcis, extends to the astragalus and to the ankle-joint, or it may begin in the scaphoid, cuboid, or cuneiform bones. According to Whitman,[1] of 1788 cases of tuberculous disease of the joints, in 54·1 per cent the hip was affected, in 36·2 the knee-joint, and in 9·7 the ankle-joint.

The pathological processes differ in no wise in the ankle from

[1] *Loc. cit.* p. 440.

those in other joints; but, inasmuch as the bones are soft and spongy, and there are numerous synovial sacs in the tarsus, wide-spread extension of the disease is likely to follow. This is particularly so when, as is most common, the astragalus is the primary site of disease. In some cases disease extends from the joint into the sheaths of the neighbouring tendons, and spreads up the leg and down the foot. When the common sheath of the dorsal tendons is involved the foot becomes bulbous, the toes pointed and pressed closely to one another. Disease spreading along the tendons may break down at a distance and form sinuses, the position of which by no means indicates disease of the nearest joint.

FIG. 195.—Tuberculous disease of Synovial Membrane of left ankle, in a girl, aged 15 years (Alexis Thomson and Miles).

Symptoms.—The patient complains of pain and tenderness, particularly over the front of the ankle, and perhaps behind the malleoli. On examination, the joint is observed to be hot and somewhat swollen. In some cases the swelling is uniform; in others it is in front or behind one or both malleoli, and the swelling has a peculiar semi-elastic character. Pressure over the front of the joint or in the immediate neighbourhood of the malleoli causes tenderness. The movements of the joint are limited, and there is rigidity of the muscles in the neighbourhood.

In the early stages a limp is only noticed at the end of the day, or after prolonged use, and after a time it is permanent. The deformity accompanying the disease varies. At first the foot is held in the plantar-flexed position; as the child rests more, the position becomes one of equino-valgus, and he is unable to bear any weight upon the foot. Equinus deformity is the most common position in disease. In some exceptional cases the foot is held in the position of talipes calcaneus. The explanation of this is, probably, that the back part of the articular surfaces is involved, and the heel is dropped, so as to avoid pressure on the tender spots. Certainly, in the early stages these abnormal positions are due to muscular spasm, and to the effort of the patient to save the limb. When equinus is present, the effect of gravity plays a part; but if the ankle is rested, and proper treatment applied, the foot can be readily induced to resume its normal position.

Sub-astragaloid disease (Fig. 197) simulates to some extent ankle-joint disease. The swelling, however, is not so marked around the

FIG. 196.—An advanced stage of Tuberculous disease of the ankle (Bradford and Lovett).

malleoli, but is below them, thus showing that the astragalo-calcaneal joint is affected; and in these cases the primary disease is frequently in the os calcis.

Diagnosis.—Briefly it may be said that in children persistent pain, swelling, and deformities of the ankle-joint of the types above mentioned are absolutely characteristic of tuberculous invasion. In a child, if an ankle-joint is constantly painful when at rest, it is usually the site of tuberculous disease. In adult life, care must be taken to differentiate rheumatism, rheumatoid arthritis, the effects of strain and fractures, and rigid flat-foot. In such cases the history of the onset and the effects of treatment, together with a Röntgen ray photograph, will be of much value.

Prognosis.—When the case is treated early, children as a rule make a good recovery, but the effects of conservative treatment in adults are not so satisfactory.

Treatment.—The same principles apply to the ankle as to other joints. Fixation of the part, sufficient rest, and protection from all jarring movements are called for, and these can be best obtained at first by rest in bed on a suitable back splint, with a foot-piece; and later, by putting on a plaster of Paris bandage

Fig. 197.—Tuberculous disease of the Sub-astragaloid joint (R. Whitman).

with the foot at a right angle, and allowing the patient to get about with crutches and a patten on the opposite foot. Thomas' knee splint is also valuable, although care must be taken during its use that no equinus or valgus is allowed to occur. If, in spite of treatment, deformity persist, gentle manipulations will as a rule suffice to overcome it, but in resistant cases it may be necessary to replace the foot, under an anæsthetic.

Adjuncts to treatment are the employment of properly applied plaster bandages over cotton wool, which exercise sufficient pressure upon and give support to the affected joint. Bier's congestive treatment is applicable and serviceable in this situation, and has

PLATE X.

Radiogram of Tuberculosis of the Os Calcis (Alban Köhler). The patient was aged 45 years. The lighter area in the os calcis was found, at operation, to be filled with caseous pus, whilst in the darker area below and posterior to the lighter area the bone was sclerosed.

To face page 314.

been successful. The new tuberculin either alone, or combined with Bier's treatment, may be given a trial.

In many instances much of the general swelling subsides, but a part often remains, and softening takes place in this and pus forms. It should be evacuated, and pure carbolic or iodoform emulsion, or Stiles' sublimated iodoform and bismuth paste (p. 24), may be freely applied to the interior of the cavity, whilst at the same time the joint is kept as immovable as possible. Turpentine and balsam of Peru are also useful applications.

When the acute process has subsided, the body-weight may be allowed to fall gradually upon the ankle; at the same time the joint should be kept fixed, and it is better to aim at obtaining a firmly ankylosed joint in good position rather than to seek for movement. The duration of treatment will be from two to three years.

Operative Treatment.—If the patient's health keeps good, although there are discharging sinuses present, it is best not to perform what may be described as partial operations, such as scraping and gouging. They open up fresh synovial sacs, and result in further spread of the disease. In many instances, despite very unfavourable appearances in and around the joint, the whole process will gradually subside if the patient is sent to the seaside, and proper fixation and protection are provided; and indeed such is a common event in children. In the case of adults conservative treatment is not so satisfactory, and early operation is called for. In almost every case removal of the astragalus is required.

Various incisions are used. Jacobson and Rowlands[1] recommend a transverse one, dividing the dorsal tendons, and "prolonged laterally as freely as is needful." This gives excellent exposure of the joint, but there is risk of infection of healthy tendon sheaths by tuberculous material. If they are already infected, a not uncommon event, for disease in the joint usually breaks through the thin external part of the anterior ligament, then the dorsal incision should always be preferred to any other, as it affords an opportunity of clearing the tendons of diseased material.

We have generally used an external incision commencing three inches above the tip of the external malleolus, and in front of the peroneal tendons, and carried forwards to the inner side of the base of the fifth metatarsal bone. This incision is nearly identical with the J-shaped external incision as used by Kocher, and recommended by Stiles.[2]

[1] *Op. sup. cit.* 5th ed. vol. ii. 1038.

[2] *Op. sup. cit.* vol. ii. p. 80.

The flap formed by this incision is dissected well inwards, as far as the internal malleolus, while the peroneal tendons with the tissues over them are hooked backward. The joint is opened by dividing the external lateral and other ligaments, and the foot is wrenched inwards until the sole points upwards. To facilitate exposure of the joint the internal malleolus may be sawn off or fractured. If the posterior ligament of the ankle and the transverse tibio-fibular band are cut, the whole joint is in full view. All synovial membrane is now cut away, particularly on the inner and posterior aspects of the joint. The astragalus is inspected; and, if it is not diseased, merely the articular cartilages are cut away; but if there is any reason to be suspicious, this bone should be removed without hesitation. The upper surface of the os calcis and the astragalo-scaphoid joint are now examined, and the synovial membranes taken away. The articular surface of the scaphoid is removed, also the upper surface of the os calcis. The latter is shaped to fit the tibio-fibular arch, after sufficient bone has been taken away from the tibia and fibula to ensure that no disease has been overlooked. In order to keep the parts in good position a long plated nail is used by Stiles. "It is driven up through the skin of the heel into the tibia for a couple of inches or so," while the assistant holds the foot in good position. We prefer to incise the tissues of the heel, and counter-sink a depression in the under surface of the os calcis to receive the head of the nail. Frequently we find it unnecessary to remove it later. Drainage is not required, if no sinus have formed in the course of the disease. The limb is placed in a MacCormac's wire splint; or, if no drainage has been used, in a Croft's plaster of Paris splint, until healed. Then, a firm plaster of Paris bandage is applied for three months, with the foot slightly inverted, so as to anticipate the valgoid deformity so likely to follow both this operation and arthrodesis.

When surgical intervention is evidently necessary, it is better to perform a radical operation such as this, rather than blindly to scrape about and dig with gouges. When the soft parts above the heel are so much diseased that excision of the ankle is not possible, then Mickulicz's osteoplastic resection of the foot may be done.[1]

In children, operations on the foot are followed by some shortening of the limb, usually not more than an inch, and the affected foot is generally smaller than its fellow, which is due partly to disease, and partly to ablation of some of the tarsal bones.

[1] Harold Stiles, *Burghard's Operative Surgery*, vol. ii. p. 89.

PLATE XI.

Radiogram of Tuberculous Osteitis of the Foot (Alban Köhler). The outline of the Os Calcis is fairly well-defined, and its structure is discernible, whilst that of the other bones is obscured, and the shadows are irregular in density and patchy, in parts indicating rarefaction, in parts sclerosis.

To face page 316.

When conservative methods and excision have failed, amputation is called for. In Mr. G. A. Wright's opinion the Pirogoff operation is preferable to that of Symes', but we regret that we cannot endorse this view. It is easier, moreover, to fit an artificial limb after Symes' amputation than Pirogoff's.

TUBERCULOUS DISEASE OF THE TARSUS AND METATARSUS

In the tarsus the medio-tarsal joint is most usually involved, and next to that the tarso-metatarsal articulation. In most cases extension of the disease occurs from the joint first affected to other parts. When the disease begins in the astragalo-scaphoid joint, the swelling is localised in front of the ankle, and the foot is often persistently abducted. Disease of every tarsal and metatarsal bone and phalangeal articulations has been seen.

At the Evelina Hospital for Children a large number of cases of tuberculous dactylitis are met with, giving rise to the condition known as "spina ventosa." These cases, unless checked, are often followed by virulent outbreaks of tubercle elsewhere.

Treatment.—If the disease is localised to one bone or joint, and comes under observation early, the affected structures should be attacked at once on account of the risk of the morbid process spreading. In children, however, excellent results can be obtained by prolonged rest, fixation, and improved hygienic surroundings. Adults do not respond so readily to conservative treatment, and in many cases operation is called for. If the tarso-metatarsal and anterior tarsal regions are diseased, then complete anterior tarsectomy,[1] introduced by Sir P. H. Watson, is performed. If tuberculous ostitis exists in the os calcis, and if it is limited to one small focus, then it may be gouged out. But, if it is at all extensive, then the whole bone should be taken away.

[1] Stiles, *op. sup. cit.* p. 78.

CHAPTER VIII

TUBERCULOUS DISEASE OF THE JOINTS OF THE UPPER EXTREMITY

Tuberculous Arthritis of the Sterno-Clavicular and Shoulder Joints, their Ætiology, Symptoms, Prognosis, Treatment—Tuberculous Arthritis of the Elbow and Wrist, Symptoms, Prognosis, Treatment—Tuberculous Dactylitis (Spina Ventosa)—Acute Miliary Tuberculous Synovitis.

DISEASE of the sterno-clavicular and of the acromio-clavicular joints has been met with, but beyond its rarity it presents no special features, and it is treated on similar lines to tuberculous disease of the joints elsewhere.

TUBERCULOUS DISEASE OF THE SHOULDER

is a comparatively infrequent affection, and according to Whitman does not average more than 2 per cent of all tuberculous joint cases. It is more frequent in adults than in children, and we have noticed its coincidence on three occasions with apical lung disease. It is difficult in these cases to say which is primary and which is secondary, yet the contiguity of the parts is suggestive of widely-spread local infection.

Pathology.—In the majority of cases the primary disease is in the head of the humerus. It rarely begins in the scapula. In occasional instances it appears to be primarily synovial.

Symptoms.—The onset is extremely gradual, and it is often preceded by a fall or a blow on the shoulder, so that some tuberculous cases are mistaken for traumatic subdeltoid bursitis. There is in both a history of accident; but in all doubtful cases, if movement by manipulation results in progressive diminution of the functions of the joint, tuberculosis of the shoulder is almost certainly present. The disease is so insidious that the patient has frequently lost the movements of the shoulder-joint before he is aware of it. It is also very chronic, frequently results in suppuration, and is associated with marked deterioration of the general health. Pain is present after a time, and is felt either in the joint itself or at the insertion of the deltoid. Tenderness is common, and is elicited at a point just external to the coracoid process or at the posterior margin of the deltoid. When the scapula is firmly held, the limitation of movements of the joint are evident. Rapid atrophy of the shoulder muscles takes place, and the enlargement of the head of the humerus can be easily felt. There is also an increase of temperature over the joint, the patient is unable to bear pressure upon it, and cannot lie on the affected side at night.

FIG. 198.—Tuberculous Arthritis of right shoulder joint, showing atrophy of the parts and changes in the outline (Bradford and Lovett).

Two forms of caries are met with: Dry caries, in which gradual destruction of the head of the humerus takes place; in the other type, fluid is formed, which distends the capsule, so that the shoulder appears fuller and broader than normal, and the depressions about the joint are lost. In such cases pus often forms, and discharges through sinuses in the axilla or in the neighbouring parts of the thorax and back. If the affection has begun in childhood the humerus is frequently shortened, owing to arrest of growth at the epiphysial line.

Prognosis.—The best that can be hoped for, without operation, is recession of the disease, with partial or complete ankylosis. Tuberculous affection of the shoulder is a more serious disease in adults than similar affections elsewhere, and the frequent coincidence of phthisis at the apex of the lung on the affected side is remarkable. It is agreed that the death-rate is higher than in tuberculous diseases of the joints of the lower extremities.

Treatment.—The same principles obtain here as elsewhere in the conservative treatment of tuberculous joints. A good plan is to flex the elbow to an acute angle, attach the wrist to the neck by a sling, place a pad in the axilla, and then draw the arm towards the chest by a bandage or by strips of adhesive plaster. In some cases, where the patient cannot be seen at frequent intervals, a plaster of Paris bandage or leather cap and splint are advisable. The weight of the limb in any case acts as a means of distraction.

Operative Treatment — Excision.—This operation should always be done earlier in adults than in children, because of the disability and loss of wage-earning power which the disease causes.

Two methods are employed : (A) By the anterior incision. (B) By the posterior route of Kocher. The flap-operation, of lifting the deltoid, is very rarely done, on account of the loss of abduction power afterwards.

(A) *Excision by the Anterior Method.*—The patient's arm is abducted to an angle of 80°, and rotated outward; and an incision four inches long is made, commencing half an inch externally to the tip of the coracoid process and carried downward, in the interval between the fibres of the pectoralis major and the deltoid. The cephalic vein is drawn aside by retractors, or it may be secured by two pairs of forceps, divided and ligatured.

The tendon of the biceps is sought for and carefully examined. It and the sheath may be quite healthy, or the tendon may be surrounded by tuberculous granulations. In some cases it is still intact, in others it is frayed out or adherent to the bone; and when the bicipital groove has formed a sinus channel, the tendon may have ulcerated away. The capsule is now freely opened right to the top of the glenoid cavity, and is raised subperiosteally from the tuberosities. The muscles attached to the greater tuberosity are now separated by a periosteal elevator, the assistant forcibly rotating the arm inwards; and then, the arm is rotated out, and the sub-scapularis detached from the lesser tuberosity and the adjacent part of the shaft. Great care is taken not to damage the tendon of the biceps. It must be kept well out of the way by retractors. If disease has extended along the sheath, the material is dissected away.

"When a limited focus of disease is present in the great tuberosity, thorough curetting, followed by the introduction of sublimated iodoform and bismuth-paste, will generally suffice. If, however, the focus in the humerus is more diffuse, the periosteum must be still further separated and the bone sawn across immediately below the disease. Care must be taken not to wound the circumflex vessels, and more particularly the circumflex nerve" (Harold Stiles).

The head of the bone may be cut away either *in situ* or after thrusting it through the wound. And the extent of the disease decides the surgeon which course he shall take. The bone is generally sawn along the line of the anatomical neck.

If a skiagram has shown that the bones are not affected, and, therefore, that the disease is primarily synovial, it is not necessary to remove more than a thin slice of the head of the humerus. In all cases the upper end of the humerus should be carefully rounded off. When the glenoid cavity is affected, a thin slice of bone is taken away, whilst, if a carious focus exists in the neck of the scapula, "the origin of the triceps is separated subperiosteally, and still more bone is removed. It is in these cases that the posterior route recommended by Kocher is specially advantageous" (Harold Stiles). All sinuses are followed up and dissected out. As a rule drainage is desirable, even in non-suppurative cases, for two or three days, and in infected cases for longer.

A pad should be placed in the axilla to prevent the upper end of the humerus being displaced inwards; the forearm is put in a sling.

Movement is usually begun in a fortnight, and particular care is taken that rotation and abduction are not lost. The pad in the axilla and the sling are retained for six weeks after the operation.

(B) *Excision by Kocher's Posterior Method.*—The incision commences at the tip of the acromion process, passes backward along the acromion process to the spine of the scapula, and is then carried down in a curved direction toward the posterior fold of the axilla, ending about two fingers' breadth above it. The acromio-clavicular joint is opened, the fibres of the trapezius attached to the spine of the scapula are divided, and the posterior edge of the deltoid exposed. The posterior fibres of this muscle are drawn forward, and the supra- and infra-spinatus muscles are detached from the outer border of the spine and the root of the acromion. The latter is now divided by a chisel or saw, and, carrying with it the fibres of the deltoid, is reflected forward over the head of the humerus.

Instead of sawing the root of the acromion, the attachment of

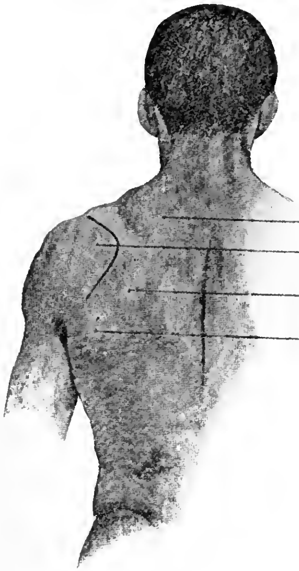

FIG. 199.

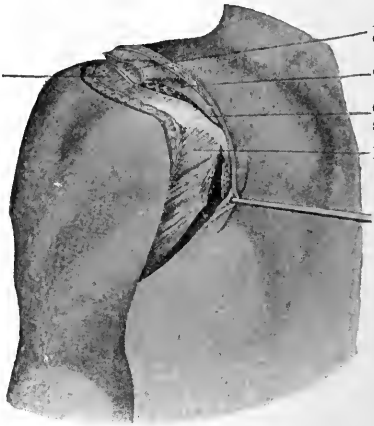

FIG. 200.

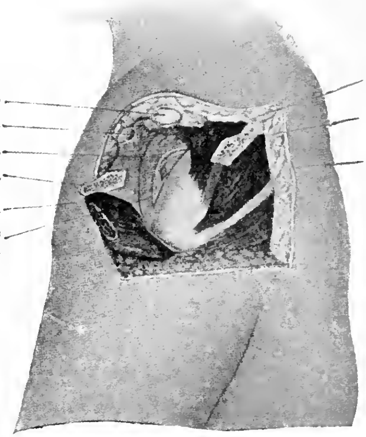

FIG. 201.

FIGS. 199, 200, 201.—Three figures illustrating Kocher's method of Excising the Shoulder-Joint (Binnie).

the deltoid to it may be separated subperiosteally and then drawn forward. The capsule of the joint is now opened, care being taken to preserve the biceps tendon. The insertions of the external rotators are then separated and held backwards, whilst the biceps tendon is hooked forwards. In order to obtain a complete view of the glenoid cavity it may be necessary to detach the subscapularis tendon upwards and inwards. After removal of the head of the humerus, an excellent view of the glenoid cavity is obtained, and any carious foci in it or in the neck of the scapula can be dealt with.

This operation has the advantage of free exposure of all parts of the joint without division of the anterior part of the capsular and coraco-humeral ligaments, and there is no subsequent displacement of the head of the humerus inwards.

The acromion process is wired to the scapula, or if it has not been divided, the periosteum with the posterior fibres of the deltoid is carefully sutured in place. Drainage is provided for a few days, and the same care is taken in preventing stiffness by passive movements, as after the anterior excision.

Tuberculous Disease of the Elbow

Tuberculous disease of the elbow may commence either in the bone or in the synovial membrane, more often in the former. Of the bones entering into the elbow-joint, the olecranon is the most frequently attacked, and then the external condyle of the humerus, while the head of the radius is seldom the primary seat of disease.[1] Some cases, especially in adults, and occasionally in children, appear to begin as a tuberculous infection of the olecranon bursa.

Symptoms.—Limitation of movement is observed early, and full extension is the first movement to be lost, whilst flexion, pronation, and supination are free. Later on, all these movements become decreased in range, until finally the limb becomes fixed midway between flexion and extension, and pronation and supination. Pain is usually an early symptom, yet it is by no means severe, and may be entirely absent. The surface temperature of the parts is often raised from the first. The joint itself is very sensitive to pressure, and this is most marked over the site of disease.

[1] I am aware that this statement may not meet with general acceptance, many surgeons holding that the head of the radius is *usually* the part to be earliest affected. In primary tuberculous synovitis the membrane about the head of the radius is, however, often the earliest site of disease.

Swelling soon makes its appearance. At first it can be detected over the radio-humeral line, at the back of the elbow; later, all the hollows are filled in, and the joint assumes a bulbous appearance. The muscles above and below atrophy, so that the swelling often appears greater than it really is. It is of a peculiarly elastic character, due to thickening of the subsynovial and other tissues, and presents the characteristics of the ordinary pulpy swelling. If the disease be left untreated, the tuberculous tissue breaks down, the skin is involved, and may become riddled with sinuses.

FIG. 202.—Diffuse Tuberculous thickening of the Synovial Membrane of the Elbow, in a boy aged 12 years (Thomson and Miles).

It is all important to detect the site of origin of the disease, and in which bone it is situated, as a timely operation may prevent involvement of the remainder of the joint. For this reason the use of the Röntgen rays is invaluable.

When the disease begins in the head of the radius, the local swelling is most marked, owing to involvement of the sac of synovial membrane between the radius and ulna, and pronation and supination are the first movements to become restricted and painful.

Prognosis. — Unless the disease is detected and treated in its earliest stage, the outlook, so far as the preservation of movement is concerned, is very problematical, and the best result that can be hoped for is ankylosis in a favourable position. In a suspected case no attempt should be made to increase the range of movement of the joint by passive movements under an anæsthetic. It causes the disease to spread, increases pain, and gives rise to greater fixation of the parts.

Treatment.—As in tuberculous disease elsewhere, measures for the improvement of the general health must be taken, and the joint carefully fixed. In early cases the elbow may be strapped with

Scott's ointment, and the forearm slung at an acute angle. Or, the Scott's ointment may be dispensed with, and the joint fixed in a plaster of Paris or poroplastic splint, support being afforded by a sling. Bier's congestive treatment and injections of tuberculin may be tried.

The result of this treatment may be partial or complete ankylosis, and in order to obtain the most useful limb, the position to be aimed at is flexion at a little less than a right angle. Should the forearm be at a greater angle when first seen, it may be rectified a few degrees at intervals of two or three weeks, and put in plaster of Paris.

After the disease has spent its activity, and if the arm is in a favourable position, the propriety of reduction of the deformity under an anæsthetic may be considered. The duration of treatment in any case will not be less than two years.

Operative Treatment.—In all cases of tuberculous elbow-joint disease a skiagram should be taken, and if a focus is found within the bone, it is generally better to operate early. In some instances, unfortunately rare, it is possible to remove small extra-articular areas of disease from the bones, and more particularly is this the case when the olecranon or the epicondyles are affected.

When it is evident that the synovial disease is growing worse under treatment, and certainly when foci of diseased bone are present within the joint, operation is called for.

Mr. Harold Stiles recommends that "when operating in the early stage of the disease, instead of proceeding to do a stereotyped excision, the first step in the operation should be a free arthrotomy, and preferably by the external J-shaped incision of Kocher." The incision commences 2″ above the external condyle, passes downwards toward the back of the external supra-condyloid ridge, through the fleshy fibres of the triceps external to its attachment. It is then continued, and ends by curling inwards to reach the posterior border of the ulna about 2″ below the tip of the olecranon. The radio-ulnar joint is opened between the anconeus and the common extensor tendon. The inner flap, including the insertion of the triceps, and nearly the whole of the anconeus, is detached subperiosteally. Kocher lays special stress upon the preservation of the anconeus along with the nerve which supplies it. The flap with the ulnar nerve is further dissected away until the internal condyle is clear. The tissues are then reflected subperiosteally off the external condyle and the head of the radius. When the condyles are bared, the elbow is fully flexed and the lower end of the humerus is protruded. The humerus is then sawn across at the level of the upper part of the epicondyles, or better still at the apex of the olecranon fossa. The upper ends of the radius and the ulna are now thoroughly cleared and thrust out of the wound. A saw cut, made at the level of the neck of the radius, severs the upper ends of the bones, care being taken to preserve the biceps tendon, and not to injure the posterior interosseous nerve.

Before the wound is closed, we ascertain if the disease is entirely intra-articular ; if tracking of tuberculous material has occurred, or sinuses have formed, the diseased material must be dissected out—a matter of considerable difficulty.

After all the disease has been removed, the edges of the wound are brought together, deep sutures being put into the muscles and superficial sutures into the skin. In the absence of pus or sinuses drainage is not required.

After-Treatment.—The method varies very considerably according to the age of the patient, the amount of bone removed, and the disturbance of the soft tissues involved in tracking out sinuses. If not more than the usual amount of bone has been removed, the forearm is placed in extension and somewhat supinated for fourteen days, Mr. Stiles's plan of bandaging the limb to the side of the chest being an admirable one. "During the next fortnight the elbow is alternately flexed and extended at periods of forty-eight hours, and at the end of the month the limb is merely supported in a sling and the child begins to use it."

"If," Mr. Stiles adds, "the disease has been more extensive than usual, the chance of a flail-like joint will be lessened if the limb be placed in the flexed position from the outset."

In adults he recommends "that the elbow be kept extended and somewhat supinated for the first two or three weeks, after which the limb is massaged and active movements encouraged. If there be a tendency to stiffness, passive movements must be persevered with. Pronation and supination may be begun almost from the first. If the joint shows signs of becoming flail, the limb should be placed in plaster of Paris in the flexed position for some weeks. If, on the other hand, it is evident that ankylosis is going to result, the patient's occupation must be taken into account in deciding as to the position in which the elbow is allowed to become stiff. In both instances the forearm should be in the mid-position between pronation and supination. Kocher points out that on no account should the forearm be placed across the front of the chest in the flexed and adducted position. He applies a splint which maintains the forearm in the supinated and vertical position, so that the ends of the radius and ulna may rest in the coronal plane against the humerus. He begins active movements after a few days and maintains the plaster."

Operation by the Posterior Incision.—The important points in this operation are to avoid injuring the ulnar nerve on the inside of the olecranon, also the connections between the periosteum and the attachments of the muscles; and it is essential to preserve the extension of the triceps tendon to the posterior margin of the ulna and the deep fascia of the forearm. In fact, it may be advantageous to split the triceps tendon vertically and carefully peel it off the olecranon and ulna on either side. The time spent over this detail is well repaid when it is desired to obtain movement of the excised joint.

The bones are sawn through as described in Kocher's operation. If disease has extended into the shafts of the bones, more of them must be taken away. The error is often made of taking too little off the bones rather than too much, on account of the fear of a flail-like joint. The sawn sections, moreover, should be curved, the lower part of the humerus convex from before backward, and the upper end of the ulna, concave. All suppurating points and sinuses should be removed. The wound is closed at its ends only, the remainder being left open.

With reference to after-treatment the same plan is pursued as in Kocher's operation. The object is to attain a firm, movable joint, and, according to Messrs. Jacobson and Rowlands,[1] the test of success is as follows: "In about four months from the operation, the patient should be able to move the new joint freely and efficiently, to dress and feed himself easily, and to lift fairly heavy weights. But it will be nine months or a year before the joint is thoroughly firm and strong."[2]

[1] Jacobson and Rowlands, *The Operations of Surgery*, 5th ed. vol. i. p. 117.

[2] For fuller details of the operative treatment of tuberculous arthritis in the elbow-joint the reader is referred to the comprehensive account by Messrs. Jacobson and Rowlands in *The Operations of Surgery*, 5th ed. vol. i. pp. 123-126, and to Mr. Stiles's article in Burghard's *Operative Surgery*, vol. ii. pp. 65-72.

Tuberculous Disease of the Wrist

Disease of this joint is comparatively rare, although tuberculous dactylitis, affecting the metacarpals and phalanges, is very common.

The local symptoms of disease of the wrist-joint are pain, swelling, limitation of movement, and atrophy of the muscles. The hand may be midway between flexion and extension, or more commonly the wrist is flexed at an angle of about 120 degrees. Swelling is first noticed on the lateral aspects of the joint, and later it extends all round the part, and gives it a bracelet-like appearance. By extension to the tendon-sheaths, disease may travel upwards to the forearm and downwards to the hand. The affection may begin in the large palmar bursa, and the condition is ordinarily known as "compound ganglion." This affection is invariably tuberculous, and is very likely to spread to the bones of the carpus and metacarpus, and to the synovial membranes.

Prognosis.—The disease is slow and chronic, and suppuration is very prone to occur in adults. It appears, too, that in them pulmonary phthisis is a frequent complication. In children the outlook is not so bad.

Treatment.—The same principles of fixation and rest apply here as elsewhere, and wooden splints, plaster of Paris, or poroplastic, are all of use. The hand should be maintained slightly hyper-extended, so as to enable the fingers to close more readily if ankylosis follows.

On account of the superficial nature of the joint, local applications, such as Scott's ointment or oleate of mercury, appear to be of service in the early stage of the disease, while compression by Bier's congestive method is a most useful adjunct to rest and fixation. Minimal doses of the new tuberculin may be given about once a fortnight.

When it is evident that the disease is making headway under this treatment, operation is called for. It should be done earlier in adults than in children, because of the greater liability of adults to suppurate, and the frequent complication of pulmonary phthisis.

Excision of the wrist may be carried out either by Lister's, by Langenbeck's, or by Ollier's method. Lister's method is a complicated and difficult one, but Langenbeck's method, by a single dorsal incision between the tendons of the extensor indicis and the extensor secundi internodii pollicis gives sufficient room for the removal of the whole of the carpus, the lower end of the radius and ulna, and, if necessary, the bases of the metacarpal bones. In some cases good mobility will be obtained subsequently, although in other cases the surgeon will be satisfied with ankylosis and removal of the disease.

Tuberculous Dactylitis or Spina Ventosa

This disease, one of the most common tuberculous affections seen at a Children's Hospital, is of importance mainly as being the starting-point for some of the most inveterate forms of tuberculosis of the skin and lymphatic glands, and it is frequently the forerunner of general infection. Spinal caries is not infrequently seen in the same patient (Ménard).

The disease may be central in the diaphysis, or peripheral in the periosteum. It usually affects the first phalanx of a finger or toe, but is quite common in the metacarpus or metatarsus.

Symptoms.—In the osteomyelitic form the compact tissue is expanded from within. Gradually the original shell of compact tissue is destroyed, and is replaced by the formation of new bone from the periosteum, yet the fresh tissue in its turn may be destroyed. The tuberculous material breaks down, and pus escapes through sinuses. At this stage of the disease, a large cavity is found occupying the site of the shaft, and around it is a thin layer of new bone (spina ventosa) (see Plates I., II., III.). In early cases the affected bone is thickened, spindle-shaped, and tender on pressure. The disease may be arrested at this stage, and the condition subside under treatment. But, more often it progresses, and involves the neighbouring joint, or extends to other parts.

One peculiarity of the disease is that it affects very young children. At the Evelina Hospital for Children, where a very large number of cases came under my notice, I have several times seen it in children under two years of age, and in patients of this age the prognosis is decidedly bad.

As showing the serious nature of the affection, I may allude to one case which was under my care for a considerable period. A child, aged four years, was seen with tuberculous dactylitis of the first phalanx of the left index finger. Under treatment this subsided, but two years later the child was brought to see me with large tuberculous ulcers on the dorsal and flexor surfaces of the forearm, and a broken-down epicondylar gland. These were all scraped or excised. The next stage in the affection was invasion of the axillary glands, which were removed. The child then developed pleurisy at the apex of the left lung, and finally an acute form of phthisis, which was the cause of death.

Treatment.—In some instances, with suitable constitutional and local treatment, including Bier's method and tuberculin, the disease subsides and the parts entirely recover. More often, and especially in hospital practice, pus forms, and operation is called for.

In early cases the fingers, or the fingers and hand, must be placed entirely at rest, and the diseased area should be covered, first by a layer of lint on which Scott's ointment has been spread, and then compressed by strapping. It is better to be patient and persistent in treatment along these lines than to be in haste to operate; but if breaking down occurs, then the disease in or on the bone must be scraped out, and the cavity treated with iodoform emulsion.

If the patient recovers, the finger will be stunted, and may be ankylosed. Too often, after scraping or excision of bone, recurrence takes place, and then amputation of the part is necessary.

Acute Miliary Tuberculous Synovitis

This affection, although far from being a common one, is nevertheless met with, especially in children, and generally in association with general tuberculosis.

In most cases the joint affection is secondary to the general affection. A child, the subject of more or less rapid tuberculosis, receives a blow on a joint, which rapidly inflames, and frequently suppurates. The pus is often of the curdy kind, and on opening the joint this is found to be studded with tubercles and extensively disorganised. Sometimes this condition is preceded by an exanthem, the most usual one being measles.

The prognosis is bad, both locally and generally.

SECTION VI

INFECTIVE DISEASES OF THE BONES AND JOINTS

CHAPTER I

ACUTE INFECTIVE OSTEOMYELITIS, PERIOSTITIS, EPIPHYSITIS, AND NECROSIS

Ætiology—Pathological Anatomy—Symptoms—Complications—Diagnosis—Prognosis—Treatment.

These diseases are due to infection of the bone by pyogenic organisms. The one most commonly found is the staphylococcus pyogenes aureus, but other micro-organisms with pyogenic properties give rise to one form or another. Thus streptococcus pyogenes is found, not necessarily in an unmixed culture, in the newly-born, and during infancy, especially when the mother has suffered from erysipelas or other infection. This organism is said to be more liable to attack the periosteum and the superficial parts of the bone, and is frequently associated with epiphysitis and involvement of the joints. Staphylococcus albus and citreus have been observed in some cases of acute bone disease. The pneumococcus can be sometimes distinguished in the pus, and it may be secondary to pneumonia or meningitis, or be an immediate cause of bone inflammation. In the latter event the infection enters the body through the lung. The clinical symptoms to which it gives rise are not so acute as in the case of the staphylococcus pyogenes aureus, and they readily subside, but joint lesions are very common.

The bacillus of influenza has also been seen, in cases of bone inflammation, associated with or following that disorder. As a rule it is not in pure culture, but is associated with the bacillus coli and staphylococcus aureus.

The lesions produced by the bacillus typhosus may or may not be attended by suppuration, and they may be periosteal or endosteal, or both. There are one or several foci of disease, and their favourite spots are the ribs, the tibiæ, and the spine. Considerable attention has been directed by Gibney and others to a periostitis occurring after typhoid fever, which he designated by the quaint name of "typhoid spine" (see pp. 360-363).

Ætiology.—Infective disease of bone is either primary or secondary. The primary causes are wounds, involving bone, such as compound fractures, gunshot injuries, osteotomy, and amputations. The secondary causes are those where infection has entered the body, and has been conveyed to the bone through the blood. It is noticeable that many cases are preceded at varying intervals of time by skin lesions, such as acne, furunculosis, eczema, intertrigo; by stomatitis, suppurative mastoid disease, or by affections of the mucous surfaces of the lung, the throat and nose, and the intestinal canal.

Some years ago, when I was investigating this subject, I advanced the theory that, even with an unbroken skin, a bruise was sufficient to determine the entry of staphylococci and streptococci into the sweat ducts. I observed that in some cases, after a bruise, the sweat ducts ceased to secrete perspiration, the apertures on the epithelial surfaces were widely open, and the ducts were full of micro-organisms,[1] which are doubtless absorbed and enter the lymphatics. Kocher believes that the cocci are intensified in virulence in the skin, and that this structure acts as a nursing ground for their further development.

Infective diseases of bone are particularly prevalent in the young, at the age of puberty. The explanation of this being the age of election for the onset of disease is twofold. Children expose themselves more to blows and injuries at that time of life, and further the activity of growth, and therefore of blood-supply, is greater at the epiphysial ends of the bones. It is quite certain, too, that the disease is more frequent in those bones which are nearer the surface of the skin, and more exposed to injury, such as the tibiæ, femora, humeri, and bones of the forearm.

The actual illness is determined either by an injury, strain, excessive exercise, or by exposure to cold, and Volkmann has described cases of osteomyelitis in which years have elapsed after recovery, and yet a blow on the affected bone has been suddenly followed by violent inflammation (relapsing osteomyelitis).

In 1889 I showed experimentally the influence of injury in determining the localisation of osteomyelitis[2] in young growing rabbits. Holes were bored with a drill into the juxta-epiphysial region of the femur, and streptococci were injected into the jugular

[1] *Guy's Hosp. Reports*, 1889. This aspect of the subject is also dealt with in an excellent article on "Acute Infective Osteitis," by H. W. Kaye, *Practitioner*, vol. lxxxii. No. 4, April 1909, pp. 503-526.

[2] *Guy's Hosp. Reports*, 1889.

PLATE XII.

To illustrate the author's Experiments bearing upon the Pathology of Acute Infective Periostitis and Necrosis. A microscopical section of the lower end of a young rabbit's femur.

a, Areas of suppuration, situated in the juxta-epiphysial junction ; *b*, cartilage cells of the epiphysial line ; *c*, epiphysial bone ; *d*, diaphysial bone.

To face page 335.

veins. Sometimes in two, and sometimes in three days the rabbits were killed, and suppurative areas were found in the juxta-epiphysial region (Plate XII.).

The connection between infection and injury is by no means always so clear. A long time often elapses between the occurrences. In these cases it is reasonable to suppose that the organisms are in a state of latent vitality for weeks and even months, and that an injury stimulates them to activity.

Pathological Anatomy.—The bones affected are, in order of frequency, the lower end of the femur, upper end of the tibia, the upper end of the humerus, the ulna, fibula, and radius; and then the shorter bones, such as the metatarsals and metacarpals. The greatest liability is between the ages of ten and fourteen, and males are affected three times as often as females. Robust children suffer quite as often as weakly ones.

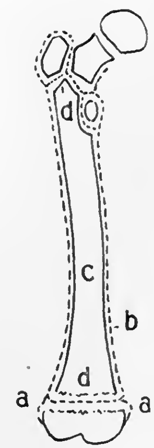

FIG. 203.—Diagram to show the Arrangement of the Periosteum at the Epiphysial Lines. *a*, epiphysial line; at this spot the periosteum, *b*, of the shaft divides into two processes (*see* text); *c*, medullary cavity; *d*, juxta epiphysial regions.

In a growing bone there are certain areas which must be carefully considered, as their structure throws light upon the clinical aspects of the disease. At either end of the shaft is a mass of young growing tissue, full of osteoblasts, connective tissue cells, and leucocytes, and permeated by large sinus-like blood-vessels. Here the blood current is necessarily slowed, and this fact, together with the excessive cell-formation at this spot, affords an explanation of this (juxta-epiphysial) region being the seat of election of the disease. In growing bone the disease is, in my opinion, in the majority of cases a juxta-epiphysitis in the first place, and the osteomyelitic and periosteal symptoms are of later advent. If we look carefully at the growing bone, the shaft is surrounded by a complete casing of soft tissues. The periosteum on the surface of the shaft, when it reaches the epiphysial line, divides into two processes. One turns inward, and is continuous with the soft epiphysial growing line, and the other proceeds upwards or downwards, as the case may be, to cover the external surface of the epiphysis, and to be continuous with the capsule of the joint (Fig. 203). An infection, beginning in the juxta-epiphysial region of the shaft, spreads in two directions, either outwards along the epiphysial line, and then, being guided by the process of periosteum before mentioned, the effused products of inflammation lift up the periosteum from the shaft; or the other direction, by which spreading takes place, is through the cancellous tissue of the juxta-epiphysial region into the medulla. During the period of growth the seat of the primary inflammation is in the juxta-epiphysial region, although clinically the periosteal aspect of the case forces itself more particularly upon our notice.

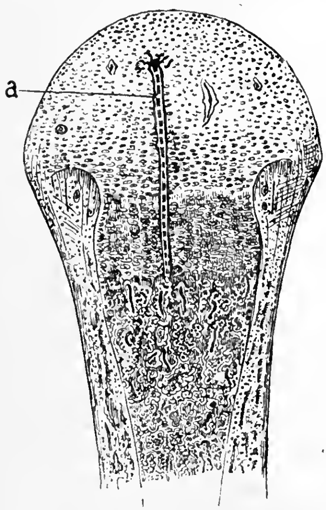

Fig. 204.—Diagram to show the Central Vascular Supply of the Epiphysis. *a*, dotted line indicates the artery passing from the shaft to the epiphysis; the continuous lines indicate the venae comites, returning blood from the epiphysis to the shaft (after Quain's *Anatomy*).

Disease may begin at one end of the shaft, and is then known as unipolar osteomyelitis; or at both ends, and it is then termed bipolar osteomyelitis. In the latter event there is a great risk of the whole of the shaft dying, as it may be cut off from its blood-supply. The epiphysis is supplied mostly by blood-vessels derived from the periosteum and ligaments attached to its surface. There is also another source of blood-supply, frequently overlooked, which is sometimes of clinical importance. In injected specimens an artery of considerable size (Fig. 204) is seen passing through the epiphysial line from the juxta-epiphysial region to the cancellous tissue of the epiphysis. The importance of this artery in carrying infection from the shaft to the epiphysis must be recognised.

It is comparatively rare for the disease to extend from the shaft to the epiphysis, but cases come before our notice, and I have seen several, in which the disease, commencing at the lower end of the femur, has destroyed its lower epiphysis, the knee-joint, and the upper epiphysis of the tibia. When this occurs, extension takes place, not as a rule through the substance of the epiphysis, but along its surface, by perforation of the process of periosteum above mentioned, which blends with the epiphysial line. In those cases, however, where the epiphysis is perforated by the disease, there is no doubt that infection is carried directly to it through the artery carrying blood from the juxta-epiphysial junction into the epiphysis. And this is the clinical importance of the arterial supply from the shaft to the epiphysis (Fig. 204).

The changes in the medulla are always those of severe inflammation, and later, pus forms. In the severest cases gangrenous patches are met with (Macnamara). In the cancellous tissue at the ends of the shaft—the juxta-epiphysial junction—the trabeculæ are broken down and disappear, and the spaces so formed are filled with greenish-yellow pus. The compact tissue is permeated by purulent channels, whilst the periosteum is lifted away from the bone, at first by serous fluid, which is later sero-sanguineous, and is finally purulent. The periosteum itself often sloughs in places, and if the patient lives long enough the pus escapes into the soft tissues. It is important to note that the veins in the bone are often thrombosed. Minute portions of the clots are detached, and give rise to infective emboli, from which originate metastatic deposits, and purulent collections in the viscera, serous cavities, and the joints.

As a rule, the extent of the lesions in the periosteum and marrow corresponds, and the bone, being deprived of its blood-supply over that area, dies. According to Alexis Thomson, it is not vascular obliteration, nor tension, nor deprivation of blood, which causes the necrosis, but death is the result of local septic intoxication; for, in an aseptic wound, bone bared of periosteum, or deprived of its marrow, does not necessarily die.

The extent of dead bone varies in different cases, and according to the time at which satisfactory treatment is initiated; the sooner, however, pus is evacuated, the less is the bone destroyed, and the less is the danger to the patient of toxæmia. Pus, formed in the marrow, makes its way towards the periosteum, either at the juxta-epiphysial ends of the shaft, or in some cases through the Haversian canals. Occasionally it does so at several points, and then periosteal abscesses will be found scattered up and down the shaft. If the case be left untreated, pus bursts through the periosteum into the soft tissues, and eventually through the skin, forming a sinus. In some cases extensive sloughing of the periosteum occurs.

It is a question as to how far, in a young growing bone, periostitis occurs apart from osteomyelitis. Most authors admit that it is an event of great rarity, yet it is quite certain that in patients who have completed growth, periostitis alone may occur as the result of injury, or of the milder infections, such as bacillus typhosus, attenuated forms of pneumococcus and bacillus coli.

In most cases the epiphysial cartilage is not destroyed, and the growth of the limb is not seriously interfered with, although it occasionally happens that the cartilage sloughs, and the results on the length of the limb are disastrous. Spontaneous fracture and separation of the epiphysis (epiphysiolysis) are not uncommon events.

It is important to distinguish between what may be called, for want of a better term, sympathetic effusion into the joint, and actual invasion by pus. By sympathetic effusion is meant a serous effusion into the joint, due to acute inflammation in the vicinity, and the fluid has been found sterile on examination. When pus invades the joint from the epiphysis, it causes an acute arthritis. This occurrence is common in infants, and produces an affection known as "acute arthritis of infants."

Repair after the Disease.—When the first products of the acute phase of the disease have been evacuated, then destruction ceases. Such parts of the periosteum and medulla as have retained their vitality resume their bone-forming functions. They develop a large amount of granulation tissue, which is ultimately transformed into new bone, and the shaft or case of new bone formed around the sequestrum is called the "involucrum." This is always perforated by apertures, called "cloacæ," which correspond to the situation of the sinuses in the soft parts, and from these apertures pus flows profusely.

If the periosteum and endosteum are extensively destroyed, there will be no formation of new bone. Where less destruction has taken place, patches or islets of new bone only will be formed. The dead bone lies within the involucrum, and is an irritant to the surrounding tissues, so that granulations grow over it, and it becomes pitted or worm-eaten, and slightly reduced in size. Eventually it becomes loose, and then is called a "sequestrum." The line of separation between the living and dead bone is effected by osteoclasts formed from the marrow, which eat into both living and dead bone at their line of junction. Unless the sequestrum is artificially removed, the discharge goes on for years, as the process of absorption is very slow. Whilst most bones are entirely reproduced by the activity of the peri- and endosteum, yet those which are normally covered by cartilage, such as the head and neck of the femur, and those which are entirely formed in membrane, are not re-developed. In infants the epiphysial and articular cartilages are not differentiated from each other, and the former is entirely within the capsules of the joints. In them also, inflammation of the epiphysis is more common than of the diaphysis, and therefore the joints are very frequently involved.

Symptoms.—For the purposes of description they may be classified as General or Constitutional and Local, and their gravity varies exceedingly.

1. *General or Constitutional.*—In the most virulent examples, delirium and severe prostration usher in the illness, and are present before there are any evidences of affection of any bone. In fact some cases die outright from general infection. In other cases the illness begins with a rigor or rigors, general illness, severe headache, vomiting, rapid pulse, and pains in the limbs. In young children convulsions may be an early symptom. The temperature generally rises in the evening to 103° or 104°, and falls in the morning, but this alternation is by no means constant. If the disease is allowed to run on unchecked, metastatic deposits take place, and then the patient lapses into the "typhoid" condition; the temperature is continuously high, the pulse small and rapid, the lips and tongue are dry, persistent diarrhœa is present, and albuminuria is constant. A cardiac bruit often develops, due to an infective endocarditis. In young children the illness is almost always of a very severe nature, and in its immediate and remote effects is one of the most serious disasters that can befall a child; but, so variable is the disease in its extent, gravity, and complications, that all grades of illness are found between comparatively slight constitutional infection and the most virulent septic poisoning. The increase in leucocytosis is considerable.

Local Signs.—In exceedingly severe cases the patient may die before the disease is recognisable locally. As a rule, after a blow, sprain, or exposure to cold, intense pain is felt in one or more of the bones, generally in the lower limbs, which increases until it is agonising. The pain remains constant at one or more spots, and does not shift about, as in acute rheumatism. Any movement of the neighbouring joint, or jarring of the limb, causes agony. If the part be pressed upon ever so gently, intense tenderness is felt, and the movements of the limb produce the same effect. Taking, for example, the leg as the site of the affection, in the early stages the part will be seen to be white, with dilated veins, producing a marbled appearance, and as the tibia is partly superficial, swelling will make its appearance early. When a deeply-seated bone is attacked, as for instance the upper part of the femur, swelling is late in appearing. It is most marked towards the ends of the bones, and tapers towards the middle of the shaft. The white appearance of the skin is replaced in a few hours or days by an œdematous redness, and by this time fluctuation can often be detected. If the serous fluid or pus is not evacuated, the swelling bursts, and a quantity of pus and blood escapes, mixed with droplets of fat, and perhaps minute particles of bone. According to Alexis Thomson [1] the presence of fat droplets and minute particles of bone in the pus indicates the medullary origin of the suppuration. If the patient is so fortunate as to escape metastatic complications, or if the neighbouring joint is not involved, the pain ceases and the fever subsides. Too often, however, in cases left to burst by themselves, the result is a fatal one. The extreme pain is due to the tension under which the inflammatory products are pent up; and if the case be one of primary osteomyelitis, the tension within the limits of the affected bone must be very great. When the incidence of the disease falls mainly upon the periosteum, accumulation of fluid beneath it pushes it away from the bone. The nature of the fluid may at first be either serous or sanguineous. In very severe cases it appears to be pure blood, pent up under high tension. I can remember Mr. Thomas Bryant illustrating the excessive pressure which existed in a fulminating case. He stated that, "when the periosteum was incised, the pent-up fluid escaped with a distinct report."

The wider the involvement of the periosteum the greater is the probability of death of the bone, and this is the more likely to occur if at the same time there is extensive inflammation of the medulla. When the affection is limited to a small area of periosteum, and is treated early, necrosis does not necessarily follow, or, if it should occur, a superficial sequestrum forms. In other instances of a less degree of severity, healing of the part may occur without necrosis; but, such cases are likely at a future time to give rise to further and possibly even more severe attacks of the disease (relapsing osteomyelitis).

Among the *local complications* are the following:—

The neighbouring joint may be the site either of simple serous arthritis, or become filled with pus due to the extension of the disease (Fig. 205). In the latter event a mistake may be made, and

[1] *Encyc. Med.* vol. i. p. 147.

the case treated as one of primary arthritis, whilst the original source of mischief is overlooked. Spontaneous fracture of the shaft of the bone has been met with several times, either before operation or during subsequent dressings. If it occurs in an adolescent with fever, osteomyelitis should be suspected. Separation of the shaft from the epiphysis, especially at the lower end of the femur, is not an uncommon event, and if the epiphysial line is at all extensively diseased much shortening will ensue. In that variety of acute affection of the ossific centre of the epiphysis known as "acute arthritis in infants," the joint may be so extensively destroyed that spontaneous dislocation occurs.


Fig. 205.—Acute Infectious Osteomyelitis of tibia, involving the knee-joint (Bradford and Lovett).

We have so far dealt mainly with cases in which the disease is limited to one bone, and is not complicated by metastases; however, when the general staphylococcal infection is very considerable, secondary deposits take place in other bones and joints, and they may be as virulent, or even more so, than the primary deposits; or on the other hand, they may be less so, and run a milder course, subsiding spontaneously.

Visceral Complications.—They may arise almost from the first, and be associated, in point of time, with the first appearance of inflammation in a bone; or, they may occur simultaneously with metastatic deposits in the bones and joints; or, it may happen that the diffusion of staphylococci throughout the blood is evidenced rather by visceral than by bone and joint complications. The formation of metastatic visceral deposits is accompanied by profound disturbance of the digestive system, a mild degree of jaundice, persistent constipation, or—what is worse—persistent diarrhœa, a small, frequent and feeble pulse and albuminuria, while the dry skin is indicative of suspension of its functions. In extremely severe cases purpuric eruptions, and in less severe, erythematous patches are seen. One of the most fatal complications is infective endocarditis, and septic emboli detached from the diseased and ulcerated valves set up thromboses in the small distal vessels, which become centres of secondary infection. The heart-muscle itself undergoes a parenchymatous degeneration, or may even be the seat of abscesses of varying size. The kidney epithelium is often cloudy, and shows degenerative changes. The liver is large, red, and soft, and the spleen is swollen. All these organs, in very profound cases, are the sites of secondary abscesses. In fact, in acute infectious osteomyelitis we are face to face with pathological changes arising from two causes: a rapid degeneration of cells owing to the toxins circulating in the blood, and the formation of secondary abscesses due to showers of minute septic emboli. In the milder degrees of the affection the symptoms of auto-intoxication or sapræmia predominate. In the virulent forms pyæmia or staphylohæmia is super-added. The gravest complications are ulcerative endocarditis, hæmaturia, persistent diarrhœa, and purpura. Even when inflammation in the bone subsides spontaneously, the patient is liable to be troubled at some future time with symptoms which point clearly to sclerotic changes in the bone, with or without the presence of a chronic abscess.

To *sum up*, the clinical picture presented by the disease is a most variable one, yet if there is one lesson to be learnt it is that of absolute promptness in grappling with the disease.

As remote complications of a local nature, shortening of a limb, due to interference with an epiphysis, is not uncommon (Fig. 206). Its extent varies from a fraction of an inch to two or three inches. Lengthening of a limb has been observed many times, and is due to extension of the inflammation to the growing line, not of such a severity as to destroy it, but merely to stimulate its activity.[1] The lengthening or shortening of an affected bone is an awkward occurrence in the case of one of two parallel bones. Thus, for instance, if the tibia be much elongated, a severe form of talipes valgus follows, and the reverse, if the fibula be the affected bone. In the forearm, lengthening or shortening of one of the bones causes considerable deformity, and partial loss of use of the hand. When a single bone, such as the femur or the humerus, in the segment of a limb is affected, twisting or curving may result, and in the femur

[1] A. H. Tubby, "Departures from Normal Length of Bones, etc.," *Lancet*, 1891, vol. i. p. 1254.

genu valgum or genu varum occurs. Joints may become contracted or ankylosed, or partially dislocated.

Diagnosis of the Affection.—1. *From Acute Rheumatism.*—In acute rheumatism the pains at first are fugitive, and shift about from place to place, whereas in osteomyelitis the pain is constant, and as a rule is defined at one particular spot. Rigors are absent in acute rheumatism, present in osteomyelitis. The skin in rheumatism is moist, and exudes an acid perspiration, whilst the tongue is moist and is covered with a whitish fur. The joints, and not the bones, are primarily affected in rheumatic fever, the lesions are usually multiple, and the effect of salicylate of soda is very quickly seen. Heart affections appear early in acute rheumatism of childhood, whereas in osteomyelitis and periostitis they are only found late in the disease, and are generally indicative of septic endocarditis. Acute rheumatism never leads to suppuration.

Fig. 206.—Loss of Growth, following Osteomyelitis of the Tibia, necessitating removal of part of the shaft (Royal Whitman).

2. *Growing pains* in children, formerly ascribed to rheumatic infection, are now believed to be a very mild form of bone infection.

3. Many cases of acute inflammation of bone have been confused with *erysipelas and cellulitis*, but the mistake ought not to arise, inasmuch as the earliest symptoms of erysipelas and cellulitis are superficial ones, and the inflammation and the redness appear first. The bone itself is not tender, and the movements of the limb, though they may be somewhat painful, are free.

4. *Erythema nodosum*, especially when it appears over the tibia and is of considerable extent, has been many times diagnosed as acute periostitis. Nevertheless, the comparatively good health

of the patient, the freedom of movement of the part, and the peculiar purplish appearance, together with the absence of rigors and pyrexia, are quite sufficient to serve as distinguishing marks.

5. In young children it is often difficult to discriminate between scurvy rickets and the onset of acute periostitis. In both there is at first the whitish, somewhat œdematous appearance of the skin and superficial tissues. In both, movement is painful, and the bones are tender on pressure, and further, the affection is frequently limited in both to one bone at first. The mode of onset, however, is entirely different in the two affections. In periostitis and osteomyelitis it is always acute, rapid, and in some cases fulminating, being ushered in by rigors and profound general disturbance; whilst in hæmorrhagic rickets fever is absent, other signs of rickets are present, and the child's general appearance is one of mal-nutrition.

6. *From infective fevers.* The most common source of error is enteric, strange though it may seem. It is only in the very late stages of severe secondary infection by metastatic deposits from bone disease that the so-called "typhoid" state is found. Still, the symptoms of typhoid fever and the blood-reaction are entirely different, and errors arise from a want of careful consideration of all the circumstances.

Prognosis.—In all forms of disease, except the most mild, the outlook is a serious one. We estimate it by the initial severity of the illness, the prominence of the symptoms of intoxication, and later, by the extent and virulence of secondary deposits. The site of the primary affection is also of importance. Disease of the vertebræ, skull, and pelvis is generally unfavourable, and in the case of a long bone, the larger the bone, and the deeper it is situated, the more serious is the outlook. Some of the most important factors, if not the most, in prognosis, are early recognition and thorough treatment. Much pain and illness are prevented, the extent of necrosis is limited, the formation of persistent sinuses is often prevented, and the patient is comparatively soon out of danger.

Treatment of Acute Suppurative Osteomyelitis and Periostitis.—It is of the greatest importance to maintain the patient's strength by every possible means. Concentrated fluid nourishment is freely supplied to the patient, and in the more intense forms alcohol is not withheld. After a preliminary purgation, saline fluids are, in severe cases, administered by the stomach or rectum, or by the subcutaneous method of infusion (Kocher). Frequent purgation is to be avoided, as we believe it is responsible in the virulent cases for the setting up of violent and persistent diarrhœa. In the fatal cases of this disease, an intense inflammation of the mucous membranes of the intestines throughout the whole length has often been found. Kocher recommends large doses of salicylate of soda. It seems that he inclines to the belief that there is a distinct connection between acute rheumatism and osteomyelitis in young people, the former being due to an attenuated virus; but, it may be again pointed out that acute rheumatism never suppurates.

Locally, the limb should be carefully sterilised, and kept entirely at rest by sandbags and a towel rather than by splints. In the earliest stages, Bier's hyperæmic treatment for twenty to twenty-two hours a day may arrest the disease. When the pain has become more pronounced, and especially when an initial rigor has occurred and the temperature is rising, the fluid products of inflammation must be evacuated. If an incision is made early through the soft tissues and periosteum down to the bone, the course of the disease is often arrested, and much necrosis is prevented. It must be made with all antiseptic precautions. Before incising, the bone should be carefully palpated, particularly the juxta-epiphysial ends of the shaft, and if tenderness is more pronounced here than elsewhere, the knife must be carried down to the bone at that spot. Even when the disease commences in the juxta-epiphysial junction, an early incision through the periosteum[1] will serve to arrest its further progress, because the inflammatory products in the interior of the bone drain out through minute channels in its substance. In those cases where the infection is of a virulent nature, the periosteal exudation is extensive, and particularly when it is in large amount at the ends of the shaft, the bone should be trephined at the juxta-epiphysial junction, so as to liberate the inflammatory products pent-up in the medullary cavity. It is certain that no harm results from this procedure, whereas much good may accrue. If pus exudes from the trephine opening in the bone, and particularly if fat droplets are present in it, then the indications are clear that we are dealing with osteomyelitis. Rough handling of the marrow is to be deprecated, and it is better to be content with two openings into the shaft at a distance from each other, rather than to carry out the

[1] Bier advises that, instead of stuffing the cavity with gauze, the edges of the wound should be brought together by sutures, 4·5 cm. apart; these are loosely tied to afford sufficient space between them for the exit of discharge, and the hyperæmic treatment is continued (Thomson and Miles).

drastic procedure of scraping out the whole of the medulla, for there is always a risk of a fatty embolism following. If, in cases where the periosteum has been opened, a small opening is found leading to the interior of the bone, it must be enlarged, and the medulla in the neighbourhood gently removed by means of a sharp spoon. It is a very rare event for the whole of the medulla to be involved, and still rarer are those cases described by Mr. Macnamara, where the marrow is infiltrated by pus, and presents gangrenous patches. Early resection of the shaft is justifiable in such cases. Exploration of the medulla is also indicated under the following conditions:—If the periosteum has been opened, and the temperature does not subside, pain continues, and if there is no evidence of metastatic deposits, then the medullary cavity must be fully and carefully explored, and the marrow cleared out. The practice in this country is rather to confine medullary operations to certain selected cases than to make them a routine procedure; whereas in France it is generally regarded as an essential part of the operation. Personally, it seems to me better to err on the side of doing too much rather than of too little. Every hour is of importance, and what is required is to arrest the disease at the earliest possible moment by every means in our power.

The question of removal of the necrosed bone at the time of the first operation, or immediate resection of the diseased shaft, should be considered, and in the hands of some it is a regular practice. Nevertheless there are grave objections to it. It is impossible at the time to see exactly what are the limits of the dead bone, and much healthy bone may be sacrificed, unnecessarily. The compact tissue may not be necrosed throughout its whole thickness. Again, unless the most careful packing of the periosteal cavity be carried out for a considerable time after immediate resection, the periosteum is likely to fall together, the cavity to be diminished in size, and the new bone to be very attenuated. I have seen at least four cases where immediate resection had been carried out in the tibia, and the periosteum allowed to collapse for want of careful and adequate packing (Fig. 207), with the result that the new bone is formed at the ends of the shaft only, leaving a hiatus of soft tissue between.[1] The limb having become useless, the patient had been condemned either to amputation or to the wearing of steel supports for the remainder of his life. When, however, suppuration has taken place

[1] In one case of this description we successfully transplanted the shaft of the fibula to fill the gap in the tibia.

PLATE XIII.

FIG. 1.

Skiagram of the leg, seen in Fig. 207. The shaft of the tibia is defective, and an attempt has been made by the author to replace it by the bone of a young rabbit, *a*. Subsequently, the shaft of the fibula was successfully transplanted into the gap.

To face page 346.

at the juxta-epiphysial junction, and the case is one of an intense character, with very grave constitutional symptoms, it may be considered advisable to remove a portion of the shaft of considerably less extent than the limits of periosteal denudation, with the object of getting rid of a focus of possible general infection. Every care must be taken to maintain to its fullest extent the cavity of the periosteum. Again, in those cases where the shaft is completely dead, lying loose in a bath of pus, it is better to remove it at once.

FIG. 207.—Flail-like Leg, following sequestrotomy of the shaft of the tibia and falling together of the sides of the tube of periosteum.

Nevertheless, such cases are very rare. If the case has been left to a late date, and extensive sloughing of the periosteum has taken place, there will not be complete re-formation of new bone, and the limb will be weak. When suppuration has extended to the epiphysis, and the joint is likely to be or is involved, the ossific nucleus should be removed, although the effects on the growth of the limb must necessarily be disastrous.

If, in spite of operative measures undertaken early, or if the patient's general condition, when he comes under treatment, is such as to give rise to anxiety, which is not relieved by immediate operation, then we must either use an appropriate vaccine or inject anti-strepto or anti-staphylococcic serum, or try both in turn.

Amputation.—When two or more bones in the length of a limb are involved, and the joint between is invaded by pus, as for instance the femur, knee-joint, and tibia, the question of amputation should be most seriously considered, and it is best in most cases to carry it out. Also, where the soft tissues are extensively infiltrated by pus, and the general constitutional condition is bad, amputation is the only resource. If, after periosteal incision and tunnelling of the bone, the temperature remains high and the patient is getting steadily worse, with or without metastatic deposits, then amputation is a necessary measure. It may be called for not only in the acute stages of the disease, although its propriety must be considered in the later stages, when a limb is the site of persistent suppuration, multiple sinuses, and sequestrotomy has failed to give relief; but also when the limb, partially or entirely healed, is flail-like or the site of severe distortions and bony ankylosis.

Sequestrotomy.—Apart from the question of immediate resection of dead bone, the best time for sequestrotomy to be undertaken cannot be stated with certainty. In all cases an X-ray photograph should be taken, so that the limits and position of the sequestrum can be ascertained. There are some indications of the date when a sequestrotomy may be undertaken. Roughly, it may be said that a sequestrum of the whole shaft of the femur will take nine months to become loose, of the tibia six months, of the fibula, radius, and ulna four months. Some guide is afforded by occasional probings through the sinuses and cloacæ. If they happen to be situated at a distance from each other, a probe may be introduced through them, and by alternate movements the looseness or otherwise of the sequestrum ascertained; or it may be possible to insinuate a probe beneath the free end of a sequestrum. Again, sequestrotomy should invariably be undertaken when it is evident that the patient is suffering from the effects of long-continued discharge, and lardaceous disease is imminent. One great advantage of leaving a sequestrum a sufficient length of time is that a firm tube of new bone or involucrum is formed, which, in the event of final recovery, gives good support to the limb. During the whole time of waiting for the separation of a sequestrum, drainage must be carried out, and the parts kept as sweet as possible.

Sequestrotomy for superficial necrosis, and in bones near the surface, such as the tibia, is a comparatively easy operation; but

PLATE XIIIA.

FIG. 2.

Transplantation of the Shaft of the Fibula into the gap in Tibia. The leg is now perfectly stable and useful.

To face page 349.

where the necrosis is extensive, and the bone is situated at some distance from the surface, such as the upper part of the femur, it is often a most difficult and may be a dangerous procedure, chiefly owing to hæmorrhage. Those who have had any experience in operating upon sequestra in the upper part of the femur in children are well aware how intensely vascular all the soft tissues are, so that a tourniquet bandage should always be previously applied, and the incision should be lengthened gradually, picking up such vessels as they are encountered one by one, and ligaturing them. A sequestrum in the neighbourhood of important vessels and nerves must be approached with respect. One of the most difficult places is the popliteal surface of the femur. In these cases it is better to make two lateral incisions, one between the ilio-tibial band and biceps tendon, and the other between the adductor magnus tendon and the inner hamstrings, and to work carefully down till the periosteum is reached. This is incised externally and internally, and carefully raised from the bone for a considerable distance. A broad copper spatula is inserted between the periosteum and bone, and serves as a guard to the vessels. This is all the more necessary, as the vessels may be wounded, not only by manipulation with steel instruments, but the artery may also be punctured by a spicule of dead bone. In every case the shell of new bone must be chiselled through for a varying length until the limits of necrosis are reached, and then with sequestrum forceps the sequestrum is removed, care being taken to leave no fragments behind, as these will invariably cause continual discharge. After the removal of the sequestrum the cavity is scraped and disinfected, and stuffed with gauze. When it is clear that every particle of dead bone has been removed, instead of stuffing it with gauze and allowing the cavity to heal by the tedious process of granulation, the space formerly occupied by the dead bone may be filled with bone grafts, or by decalcified bone, which has been preserved in sterilised glycerine, or the Mosetig-Moorhof method may be employed.[1] When the shaft of a long bone, such as the humerus or femur, has been completely resected, we may use the fibula from the same individual to fill the gap, or else a tibia from a recently amputated limb. When the shaft of the tibia is removed for necrosis, a large portion of the adjacent

[1] The cavity is thoroughly disinfected and dried by a current of hot air, and is filled with a mixture of powdered iodoform (60 parts), oil of sesame and spermaceti (each 20 parts). This mixture is semi-fluid at a temperature of 150°. The soft parts are sutured without drainage.

fibula may be transplanted. Other methods of obliterating the bone cavity, left after sequestrotomy, are given in the 4th edition of Binnie's *Manual of Operative Surgery*, vol. ii. pp. 156-66. The persistence of discharge and of sinuses always indicates the presence of necrotic fragments, and in some cases several operations are necessary. Sequestra of the pelvis and of the skull are difficult to treat. From the former they are difficult to remove, owing to the complexity of the structures in the neighbourhood, and the depth at which the bone is often situated, and the same remark applies to the vertebræ. In the case of necrosis of the skull, on account of the risk of septic infection spreading to the meninges, early interference is desirable. Care must be taken not to remove healthy as well as diseased bone.

Other Forms of Infective Osteomyelitis and Periostitis.—Most cases of osteomyelitis and periostitis are due to infection by the staphylococcus aureus, but any micro-organism of pyogenic properties may cause these diseases, although the form they assume is of much less severity. Thus the staphylococcus albus will experimentally produce osteomyelitis, although a much larger dose is required than in the case of the aureus. Staphylococcus citreus is intermediate between the aureus and albus in its power of producing pus. Streptococcus pyogenes is, as stated above, rarely seen in pure cultures; it is met with, however, in the newly born if the mother has been the subject of erysipelas or other infective disorders. Streptococcal bone lesions run a shorter course than staphylococcal, and are more acute while they last; suppuration is earlier, more diffuse, and abundant.

Serous or Albuminous Periostitis and Osteomyelitis are very rare forms of the disease. They usually occur in one bone only and in one part of it. Serum is found beneath the periosteum and in the medulla. It never becomes purulent, nor does the bone die. It has been shown that the disease is due to the irritation caused by an attenuated virus.

In reference to the pneumococcus, the incidence of infection falls more commonly on joints than on bones. Pus forms in some cases, frequently necrosis of bone follows, but recovery is the rule.

We have met with one case of osteitis due to bacillus coli, the organism being found in pure culture in a portion of the sacrum removed.

The notes of the case are as follows:—

Case 11.—A lady, aged 55 years, had suffered from the age of 20 years from pain over the sacrum, and at that time she had a discharge of pus from the side of the lower end of the coccyx, which ceased spontaneously. Then followed symptoms of colitis, and finally the appendix was removed. Two years later the pain over the sacrum re-commenced, and she was advised to rest, as it was thought the disease was tuberculous. Then a superficial abscess formed, which did not close, but left a sinus, at the bottom of which was bare bone. An operation was undertaken and some sclerosed bone removed; no sequestrum was found. The wound then closed, but re-opened in three months. A second operation was done, and a considerable piece of the sacrum in the neighbourhood of the left sacro-iliac joint removed. Dr. Butler Harris examined the bone and found B. coli in pure culture. The patient was vaccinated and ultimately recovered completely, and has remained well for three years.

Periostitis and osteomyelitis arise primarily by the spreading of infection from the adjacent soft tissues. Examples of this type of the disease are seen in compound fracture, gunshot wounds, and after operations on the bones and joints, where aseptic technique has been faulty. Inflammation of the soft tissues of the skull or of those covering the jaws is occasionally followed by acute inflammation and death of the subjacent bone. Where the marrow is exposed, as in an amputation stump, and if the case has become contaminated, osteomyelitis follows and spreads a varying distance up the bone. In all such cases, symptoms due to the bone-lesion and to metastatic deposits are seen.

Chronic osteomyelitis supervenes on the acute or subacute form, either being directly continuous with the primary attack, or an interval elapses before bone-symptoms re-appear. They may be indicative of hyperostosis or sclerosis, or suppuration with necrosis may follow. "Quiet necrosis," or necrosis without suppuration (Paget), is due to an attenuated form of infection. It is difficult to distinguish it from tuberculosis, syphilis, or sarcoma, and frequently requires an exploratory incision, supplemented by bacteriological and microscopical examination, before a diagnosis can be made.

Acute traumatic periostitis, such, for example, as that which results from a blow or kick on the shin, rarely suppurates, unless the patient is in bad health. We have seen, however, in a diabetic subject very extensive suppuration and denudation of the tibia after a slight blow. The usual course of events in a healthy person is for a swelling of limited extent to form. It is painful, tender to the touch, and fluctuates, but does not suppurate. The fluid may be either serous or sero-sanguineous.

The treatment is very simple, viz., rest to the part and cooling lotions at first. In some cases, absorption of the fluid may be hastened by counter-irritants or mercurial unguents. In other cases, where fluid is persistent, aspiration is useful. There is very seldom any necrosis of bone, although frequently a thickening remains at the spot, giving rise to a traumatic node.

CHAPTER II

PERIOSTITIS AND OSTEOMYELITIS OF THE SPINE

Degrees—Causation—Parts of the Spine Affected—Symptoms—Complications—Diagnosis—Prognosis—Treatment.

THESE affections, although rare, are of considerable clinical importance, because of the serious symptoms and great mortality they cause, and the difficulties of diagnosis and treatment.

Three degrees of *spinal affection* are recognisable :—

1. A comparatively mild form, from which the patient usually recovers, when there is inflammation and thickening of the periosteum, which subsides without causing any apparent denudation of bone, and leaves the spine in a practically healthy condition.

An example of this type came under my notice in 1902 :—

CASE 12.—An acute attack of stomatitis in a girl, aged $4\frac{1}{2}$ years, was succeeded by sudden pain in the back of the neck, which became very œdematous and thickened. The swelling lasted four days and then passed away, leaving the neck stiff. When the child was seen by me, the neck was still stiff and rigid, and the head inclined to the right shoulder. The loss of movement was absolute, the normal cervical curve forward flattened, and thickening was present about the transverse processes. With recumbency, and afterwards with the support of a leather-collar, complete recovery took place, followed by entire disappearance of the deformity and restoration of free movement in every direction.

2. A severer form, involving the periosteum and superficial layers of bone, with much inflammatory softening, sometimes suppurating, and sometimes not.

CASE 13.—In 1901 I saw, with Mr. Huxley, a girl aged five years who, five weeks previously, had been seized with an illness of a doubtful nature, complicated by double pneumonia and gangrenous stomatitis with alveolar necrosis. She then complained of pain in the lower part of the back and down the legs. On looking at the back there was a large prominence visible, involving the second, third, and fourth lumbar vertebræ, but no paralysis was present. No pus formed, but with suitable treatment, such as a spinal pillow (see p. 140) and recumbency, and afterwards wearing a spinal support, good recovery ensued. Eleven months after the first onset of the illness, the back was absolutely well. Movements were good, and there was noticeable only a slight flattening of the lumbar curve.

3. The intense form in which osteomyelitis predominates. In this a vertebra, and as a rule one vertebra only, is affected. Either a single purulent focus exists, or several scattered foci are present, in the spongiosa of the body or arch. This form is very dangerous to life, having a mortality of over 50 per cent, death being due either to pyæmia or to extension of pus into the spinal canal, pleural or peritoneal cavities.

CASE 14.—In 1895 a girl aged 10 years came under my notice, the subject of marked deformity of the cervical vertebræ, the head being deviated to the right and absolutely fixed. The whole of the cervical vertebræ were immobile, and had been so since an attack of scarlet fever a year previously. A discharging sinus was situated in front of the right sterno-mastoid muscle. From the history there was no doubt that this was an example of osteomyelitis of the spine.

Causation.—Spinal attacks such as these are preceded by septic affections, boils, whitlow, stomatitis, acute nasal and naso-pharyngeal affections, mastoiditis, puerperal sepsis, or osteomyelitis elsewhere. Pneumococcic and scarlatinal periostitis of the spine are described by Chipault.

In the pus, the staphylococcus pyogenes aureus is most frequently found, then the streptococcus pyogenes; once the staphylococcus pyogenes albus, and once the micrococcus tetragenus, were met with. In one case the first three mentioned were found together.

The disease is most common in children and adolescents, although adults have suffered, one case recorded being in a woman aged 46 years.

Males are about twice as liable to the affection as are females, and this, coupled with the vulnerability of the lumbar spine, points to a traumatic factor.

Parts of the Spine Affected.—Any part of the spine from the suboccipital region to the sacrum may be involved, but the region most frequently attacked is the upper lumbar. The cervical region, if we include the suboccipital cases, is about as often attacked as the dorsal. But, bearing in mind the relative numbers of the dorsal and cervical vertebræ, it will be seen that the dorsal vertebræ are the least frequently affected. As we have already stated, the general rule is for a single vertebra to be attacked, and the centrum rather more frequently than the arch.

Symptoms.—They vary according to the degree of the affection and the locality involved. In the periostitic forms there is a history of some septic disorder, succeeded by local pain, tenderness, loss of mobility, and that osteophytic proliferation so often seen in subacute spinal inflammation, but rarely in the acute form. No implication of the meninges or cord follows, although pressure on the nerve-roots may cause pain. These cases show a striking power of recovery.

In the violent or fulminating type the symptoms are analogous to those of osteomyelitis of the limbs. The sudden onset, the initial rigor, the early delirium, the signs of general septic intoxication, rapidly deepening in intensity, are all present, and persist until pus is found and evacuated, or the patient dies either from exhaustion, metastatic deposits, meningitic and myelitic complications. The local symptoms are excessive tenderness of the affected portions of the spine, agonising pain on attempting to move the patient, marbling of the skin and distension of the superficial veins.

If the neural arches are the seat of inflammation, local swelling, and inflammatory œdema, and later on fluctuation are in evidence. But, when the bodies are affected, local signs are not found, on account of their depth, and the diagnosis rests on the history of the affection, the nature of the general symptoms, and the exceedingly acute pain and tenderness, which the patient refers to some part of his back. Nerve-symptoms are more common early in the illness when the neural arches are affected, and they comprise hyperæsthesia, paresis, increased reflexes, paralysis of movement, of sensation, of micturition, defæcation, and finally convulsions. Marked widening of the neck from an inflammatory œdema (Makins and Abbott), severe headache, vertigo, and convulsions are valuable signs in the cervical region. And in the lumbar area, flatulence and distension of the abdomen are prominent symptoms when the vertebral bodies are inflamed, so that the condition has been diagnosed as an abdominal and not a spinal one. Suppuration occurred in 24 of 62 cases of spinal osteomyelitis.

As the disease progresses in the bodies, the focus enlarges, approaches their surfaces, and finally perforates the superficial layers, raising and destroying the periosteum. At this stage the condition is somewhat similar to that which we have described as the "sessile" abscess in Pott's disease, p. 102, save that the process, instead of being tardy and indolent, and taking weeks or months to develop, is acute and violent, taking a few days only. Having reached the surface of the vertebral body, the pus may burrow or migrate again, as is described under Pott's disease, and a mediastinal, psoas, or other collection rapidly forms, and that with terrible and destructive rapidity. Thus, according to the region involved, we may find a retro-pharyngeal abscess, a mediastinal collection, perhaps bursting through into the pleural cavities, a psoas abscess, or a pelvic abscess. Or, a collection on the front of the lumbar vertebræ may involve the peritoneum and set up peritonitis. Corresponding with such complications, asphyxial symptoms, difficulty in swallowing, pleuritic pain, shortness of breath, psoas contraction, and peritonitic symptoms may be met with. In the relatively fortunate cases of infection of a neural arch, fluctuation pointing directly to the surface may be expected.

A still graver complication, and one which arises very frequently in spinal osteomyelitis, is perforation of the pus into the extra-dural space within the spinal canal, setting up meningitis which runs on to myelitis. This occurred in 15 of 62 cases. Convulsions, delirium, paralysis, coma are seen in these cases, the symptoms varying according to the level of the segment attacked. Severest of all are the nerve symptoms met with in upper cervical and suboccipital cases, the pus passing up through the foramen magnum and setting up a virulent basal meningitis.

Diagnosis.—The diagnosis, or at all events a diagnosis sufficiently accurate to be of much value in treatment, is exceedingly difficult. The patient is so ill, and very likely comatose, that it is often impossible to make out those small differentiations on which exact localisation hangs. If an arch is affected, objective signs may be detected, but with a centrum as the starting-point the case will very likely have run on to meningeal infection, or else grave pyæmia, before the exact site can be ascertained. All that can be said is that here, as elsewhere, diagnosis depends on an accurate knowledge of the natural history of the condition as above sketched. If it is possible to examine by the X-rays, the position of the affected vertebræ may be localised.

Prognosis.—Wullstein states that the mortality in 53 cases was 56·6 per cent, and that death, usually due to pyæmia, occurred during the second week. With the bodies affected, 75 per cent died, whereas with the neural arches attacked, $33\frac{1}{2}$ per cent succumbed, *i.e.* the prognosis is much more grave when the bodies are affected, because the difficulties of early diagnosis and of reaching the focus, even if diagnosed, are greater; there is every probability of extension to the great serous sacs of the body; and the type of disease is often fulminating in character. All the sacral cases died, 4 out of 5 suboccipital, whilst the dorsal and cervical showed the lowest mortality.

Deformity is rarely noted, either during the disease or subsequently, and only once has any considerable permanent prominence been recorded.

Treatment.—The rapid onset of pyæmia in these cases is due to the development of pus deeply situated and under considerable pressure, so that metastatic abscesses or profound toxæmia speedily arise. The pus cannot escape and absorption is favoured. This is, unfortunately, only too well illustrated in the sacral cases. Treatment must be early, and consists of incision and free drainage. The formation of sequestra, save in arch cases, is rare, so that operations more elaborate than are necessitated by the locality and depth of the pus are uncalled for. All that is required is to obtain a free exit for it.

In cervical cases the focus should be attacked from behind the sterno-mastoid, and in dorsal cases by a procedure similar to that of Ménard for sessile tuberculous collections (p. 178). Psoas abscesses are reached, retro-peritoneally, in the iliac fossa, and sacral collections through the rectum or para-sacrally, or through the great sacro-sciatic notch.

Infection of the spinal canal calls for laminectomy, and metastatic abscesses require appropriate measures.

Should a favourable result ensue, prolonged rest on a suitable bed, and eventually some form of support or corset will be called for. In the case of recovery no deformity results, because, differing from tuberculosis, periosteal re-formation of bone is free.

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ACUTE OSTEOMYELITIS OF THE HIP

In infants this affection is identical with acute arthritis, and may result in separation of the epiphysis of the femur, destruction of the head, and dislocation of the joint. Some of the latter cases may be mistaken for congenital dislocation. The pathological form of displacement is known as floating pseudo-arthrosis, or *pseudo-arthrose flottante*.[1] In older children the process is less violent than in infants, and it is followed by the formation of abscess. It is difficult to distinguish it from acute tuberculosis in that situation, and very often the diagnosis is not made until inoculation and culture experiments have been carried out.

Among the more remote results of this affection coxa vara is to be reckoned.

Treatment.—The treatment consists of early evacuation, rest, weight-extension, and protection to the joint.

[1] Du Croquet et Bésançon, *Presse méd.* No. xv., 1903.

PLATE XIV.

Osteomyelitic Coxitis, Right Hip (Alban Köhler). The right acetabulum is enlarged, and its outline is ill-defined. The outline of the right caput femoris is not clear, it is distorted, broadened, and its substance is more transparent than the left. In the right intertrochanteric region there is a heavy deposit of calcareous material. Note also the thickening of the upper part of the shaft of the right femur. In tuberculous coxitis this is rare ; and in this disease the evidences of thickening and inflammation of the soft tissues in the neighbourhood of the hip are greater than in osteomyelitis. This radiogram was taken from a boy aged 10 years.

To face page 358.

PLATE XV.

Osteomyelitis of the Tibia following Enteric Fever, "Typhoid Osteomyelitis" (Alban Köhler). The patient was 36 years of age, and had had, 3 months previously, a severe attack of enteric fever. About the middle of the shaft of the tibia is a clearly-defined lighter area, oval in shape, and estimated to be 2 cm. long and 8 mm. broad, which was diagnosed as an abscess. The periosteum and subjacent cortex of the anterior part of the tibia are much thickened.

To face page 359.

CHAPTER III

INFECTIVE DISEASE OF THE BONES DUE TO ENTERIC (TYPHOID) FEVER

General Remarks—Affections of the Bones—Symptoms and Treatment—Enteric or Typhoid Spine—Symptoms—Duration—Pathology—Diagnosis—Treatment—Bibliography.

THE length of time during which the bacillus of enteric fever exists in bone is remarkable. It has been found in bone-marrow even as long as seven years after the attack of fever. The congestion of the medulla which occurs in this fever is favourable to the deposit of bacilli in it, and they only await the stimulus of injury to be stirred into activity. The favourite sites of bone affection are the vertebræ, the ribs, and the tibiæ. The marrow and periosteum are often simultaneously affected, so that when an abscess forms, for example on the tibia (Plate XV.), the pus beneath the periosteum communicates with that in the medulla by a narrow opening through the compact tissue. Many cases, however, do not go on to suppuration, and this is especially so in the vertebral column, thus forming a contrast to the virulent forms of spinal osteomyelitis. It is comparatively rarely that extensive necrosis is seen after enteric fever. Whilst in a number of instances pus is not formed, the bone remains thickened, sclerosed, and painful for a considerable time.

Symptoms.—It is rare for the bone-affection to occur during the attack of the fever, and more often it follows from the seventh to the twelfth week after its onset. The bone-lesion is attended by little or no fever, and no constitutional symptoms. At first several of the bones are painful, though ultimately the affection becomes localised in one or more of them. Sometimes redness and œdema are seen in the superficial tissue, and there may be swelling and fluctuation. The symptoms subside completely, in some cases, without suppuration ; in others, pus forms. Again, the symptoms may subside for a time, and then re-appear, this re-appearance being associated with a chronic thickening of the bone. As a rule, necrosis does not follow.

The outlook is satisfactory if the typhoid bacillus alone is present; but, if it is a case of infection mixed with streptococcus or staphylococcus pyogenes, necrosis follows, and the ultimate recovery is delayed.

In all cases the examination of the patients' blood gives the typical enteric reaction.

Treatment.—In the non-suppurative forms, rest to the part, mild counter-irritants, and in the case of the tibia the continuous pressure of an elastic rubber bandage, will often be sufficient. When fluid forms, it is usually sufficient to aspirate it; but in some cases, particularly the ribs, free incision and scraping away of the wall of the abscess cavity is required.

Enteric or "Typhoid" Spine

Synonyms—French, *La spondylite typhique*; German, *Spondylitis typhosa.*

Typhoid spine was first described by Gibney in 1889. It is a rare condition, only 50 to 60 undoubted cases having been recorded up to the present time. Although sometimes excruciatingly painful and disabling, it runs a benign course, no case having hitherto required operation. Therefore, in some instances the exact nature is somewhat conjectural, yet general considerations, the symptoms, and the skiagraphic results enable one to form an accurate opinion.

Symptoms.—The most constant is pain in the back coming on during the course of typhoid fever, or as is much more frequently the case, commencing during convalescence. In several patients the onset has been preceded by resumption of the occupation, involving perhaps heavy manual labour, a sequence suggesting the influence of traumatism. The pain may be spontaneous in a recumbent patient, and become exaggerated and often very intense on movement; or it may be evoked by movements only and be quiescent during the intervals. In the great majority of cases the painful segment is lumbar, lumbo-dorsal, or lumbo-sacral. This is probably because the lumbar portion of the spine is more vulnerable to strain, and is subjected to greater pressure during convalescence than the regions higher up. The upper lumbar region seems especially liable to attack. Silver has suggested as additional reasons for this, the greater amount of cancellous tissue, that is, of suitable nidus for the typhoid bacilli in this locality, and the possibility of direct infection from the lumbar lymphatic glands. The pain may be constant or paroxysmal. It may be localised or radiating, or referred to the abdomen, lower limbs, or testicles. Under certain circumstances it may be of such a character as to suggest the possibility of perforation having taken place.

Locally, tenderness, swelling, and, very occasionally, redness may be present; actual suppuration is excessively rare. (Cf., however, the cases of Halsted Myers and Guyot.)

The temperature is raised, generally from 100° to 103°, early in the attack; and it falls to normal in from one to four weeks, long before the pain, stiffness, and disability disappear.

Spinal symptoms, such as paræsthesia, anæsthesia, hyperæsthesia, spasmodic contractions, and alterations of the knee-jerks, usually increased, may be present, or the neurotic element may be prominent, as in Osler's cases.[1] Root symptoms, however, are only of a temporary character, and fortunately so, since even ataxia and loss of control over the sphincters have been noted.

The deformities observed have been kyphosis, scoliosis, and local swelling and thickening. Myers states that kyphosis was present in 20 of 56 cases, or in about 36 per cent. It is usually slight, and the upper lumbar region the part affected. Whether it subsequently recedes is a doubtful point, for Silver points out that apparent disappearance may simply mean that a slight prominence is masked by increasing flesh.

The duration of the subacute stage is considerable, and runs into several weeks or months. Complete cure, save for the deformity, and perhaps some stiffness, is the rule, and takes on an average about eight months—varying from a month to a year or so.

Pathology.—The symptoms and local signs point to an osteomyelitis, with a varying amount of periostitis, perichondritis, and œdema invading neighbouring parts. No clinical case of typhoid spine itself has as yet come to autopsy, followed by microscopic and cultural examination of the parts; but the condition of the bone-marrow, especially that of the spine, has been studied in typhoid cases, especially by Quincke and more recently by Fræenkel. The

[1] Osler, "On the Neurosis following Typhoid Fever, known as the Typhoid Spine," *Johns Hopkins Hosp. Rep.*, vol. iv., 1895.

presence of typhoid bacilli in the vertebral bodies (as well as in ribs, sternum, and elsewhere) has been abundantly demonstrated. Naturally their numbers, distribution, and virulence vary, and correspondingly the microscopical signs due to the re-action of the invaded tissue. Thus more or less increase of the leucocytes, giant cells, presence of blood extravasations, and a network of fine fibrin filaments enclosing necrosed cells and *débris* may be observed. That is to say, the typhoid patient must often be on the verge of a spondylitis, and a little strain or trauma alone is needed to turn the scale.

As to the method of the production of kyphosis, Wullstein is of opinion that it is due to grouping of the bacteria towards the anterior portion of the bodies, with subsequent absorption of bone and development of deformity. As often as not, kyphosis appears much too early, acutely, and rapidly to be explained thus, and the study of radiograms of these cases suggests that it is rather the result of periostitic changes, with softening of ligaments and disorganisation of one or more intervertebral discs. What is actually observed is disappearance, more or less complete, of an intervertebral disc, with approximation and synostosis of the vertebral bodies above and below it. And as our studies elsewhere show—a solution and disappearance of the discs, especially in a normally lordotic region of the spine, leads to kyphosis. And, in this particular case the prolonged recumbency, muscular wasting, and ligamentous relaxation of typhoid fever are all in favour of obliteration of the lumbar lordosis. In fact, a perispondylitis, with œdematous softening of the spinal ligaments and disorganisation of the discs, is sufficient to account for the local signs.

The **diagnosis** should not present much difficulty. The presence of, or more often, the recent history of enteric fever; the acuteness of the onset; the character of the pain; the elevation of the temperature, and (almost always) the absence of suppuration, differentiate it from Pott's disease. It must be remembered that the amount of the deformity described in these cases, although not great, would correspond with a tuberculous spondylitis of a very considerable degree of severity, since, as we have seen, kyphosis of the lumbar region of the spine is not very readily set up.

Treatment.—The pain must be relieved by local or general anodynes, and the parts put at rest by fixation and immobilisation of the spine. Recumbency alone is not sufficient save in the slightest cases. The arrangement used by the writer in Pott's disease, consisting of a spinal pillow and weight-extension (vol. ii. pp. 140-1), is comfortable to the patient and easy of application. Fixation in the plaster of Paris jacket has been used, but typhoid cases are not in a condition to stand much manipulation, and the spine itself may be so excruciatingly painful that nothing at all can be undertaken except with the help of a general anæsthetic. Under such circumstances some surgeons may prefer to fashion a plaster bed. In convalescent cases the application of a plaster of Paris jacket is a good plan. It may be done with the patient recumbent —in the latter case a Goldthwait frame (Fig. 97) is of great utility— the choice of position depending on the amount of manipulation the patient is able to bear. Some surgeons apply a spinal brace, that is, a form of splint such as Taylor's brace, in order to avoid the trouble entailed in the application of gypsum; but such appliances need considerable fitting, and are less comfortable and secure than plaster. Undoubtedly, at a later stage, spinal supports, especially the poroplastic felt corset, strengthened by metal strips, are indispensable.

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CHAPTER IV

INFECTIVE SYNOVITIS AND ARTHRITIS

Occurrence—Types of Cases—Staphylococcal and Streptococcal Arthritis—Acute Arthritis of Infants—Gonorrhœal Arthritis, Types, Ætiology, Joints Affected, Symptoms, Diagnosis, Prognosis, Treatment — Pneumococcal Arthritis — Arthritis and Scarlet Fever, Enteric Fever, Influenza, and Dysentery.

A NUMBER of infectious diseases are complicated by inflammatory joint symptoms. Those which are of clinical interest are found in the course of septicæmia, pyæmia, gonorrhœa, pneumonia, enteric fever, and exanthemata. Joint complications have been met with in association with cerebro-spinal meningitis, diphtheria, dysentery, erysipelas, glanders, influenza, measles, scarlet fever, smallpox, tonsillitis, typhus fever, after the use of sounds and catheters, and in many forms of malaria.[1]

Infective arthritis may be divided into four classes:—

(1) Simple infiltration of the subsynovial tissues, and slight synovitis.

(2) Effusion of serous fluid into the synovial sac—synovitis.

(3) Infiltration of the peri-articular tissues—plastic inflammation.

(4) General destructive arthritis.[2]

The prognosis in the first and second classes is good, and complete recovery takes place. In the third, some degree of functional disability follows. In the fourth variety ankylosis is probably the best result that can be expected. In the very severe type spontaneous dislocations frequently occur. In many of the cases, except those distinctly due to septicæmia, pyæmia, and puerperal fever, and in some cases of pneumococcic arthritis, the

[1] A most troublesome form of arthritis, followed by ankylosis of the hip-joint occurred in a captain in the Royal Navy, who had contracted Malta fever. He regained, however, partial movement at the hip under our care.

[2] Howard Marsh, *B.M.J.*, Dec. 1902.

affection in the joint runs its course without any very great damage; and, even if suppuration occurs, an early incision often obviates extensive destruction. The organisms which are found are either staphylococci or streptococci, or that peculiar to the primary disease.

As a result of infective arthritis of a mild nature, changes are sometimes set up in the joint which are indistinguishable from arthritis deformans.

With regard to treatment, in the milder cases that for synovitis is generally sufficient. In suppurative cases the joint must be freely incised, washed out, and drained. If there is any doubt as to the presence of pus in the joint, an exploratory needle should be used, and, as a broad rule, if the fluid so obtained is found to be cloudy, it is better to make an incision into the joint than to wait until pus forms. In the case of the knee, an extensive U-shaped incision, dividing the ligamentum patellæ, is advisable. The knee should be fixed in the flexed position, until the acute symptoms have subsided. By this method thorough drainage of the joint is ensured. The knee can be extended and the patellar tendon sutured when repair begins.

We will now pass on to the consideration of special types of infective arthritis.

Staphylococcal and Streptococcal Arthritis

The articulations are, without doubt, parts of the body very susceptible to septic organisms. According to Hoetzel this is due to the viscid consistence of the synovia, which protects micro-organisms from the action of the bactericides in the body-tissues.

Pus-producing organisms of this type are either introduced into the joints by penetrating wounds, or a neighbouring suppurative focus bursts into the joint cavity, as in "acute arthritis of infants"; or, the organisms are circulating in the blood, and a blow, exposure to cold, and other conditions which we at present do not understand, determine the localisation of the arthritis.

The effects of bacterial invasion of a joint vary from slight synovitis to rapid destruction of the articular tissues and utter disorganisation of the articulation, so that the joint-cavity is a mere bag of pus, in which lie the inflamed and carious ends of the bones. In the latter event, too, the peri-articular tissues are intensely inflamed, and the limb is reddened, œdematous, and swollen for a variable distance. So that, clinically, we see three forms of septic arthritis, acute serous, acute purulent, and plastic.

The *symptoms and signs* vary with the degree and intensity of the inflammatory process, from a transient blush on the external surface of the joint, with effusion of a small quantity of fluid, to an intensely angry reddish-blue discoloration, with a fully distended capsule, and complete loss of the functions of the joint. The constitutional symptoms, too, show the same divergence. In purulent synovitis the attack is ushered in with rigors, rapid rise of temperature, succeeded by general prostration, and occasionally by evidences of metastatic deposits—the precursors of pyæmia. Movement is lost in the joint and it is held rigidly, any slight jar giving rise to agony. If the patient should doze, he is awakened by sudden intense pain, and often screams.

When the disorganisation is complete, the joint becomes unduly mobile, and the ends of the bones grate together, whilst the gravity of the general condition deepens. In rare cases of pyæmic and more often of infective arthritis, the signs and symptoms are not so well defined as we have mentioned, and a joint may fill with pus without causing serious inconvenience to the patient, or without grievous damage at any rate at first to the joint structures.

Prognosis.—This necessarily depends upon the causation, the virulence of the micrococci, and the degree of affection of the articulation. In serous and plastic inflammation, and in some cases of pyo-arthrosis, the joint recovers completely or nearly so with timely treatment. Generally, if pus has formed, the joint is permanently damaged, and the best result is ankylosis; and some types of infection are so acute and virulent, and so rapid in their action, that not only the limb, but the life of the patient is in imminent jeopardy.

Very severe forms of acute septic arthritis are seen when a chronic abscess in the articular ends of the bones bursts into the joints, or when a suppurative bursitis extends through the capsule, or is introduced into it by carelessness in operating. We are all aware of the disastrous results of even the minutest slip in aseptic technique in the removal of loose or displaced semi-lunar cartilages from the knee-joint.

The **treatment** is that of inflammatory and purulent affections described elsewhere, modified, however, by considerations special to the structures involved; the parts must be kept at rest, pain being relieved by general anodynes and by weight-extension. During the progress of the disease the limb is held in such a position that, if limitation of movement or ankylosis follows, the part will be of most use afterwards.

In serous synovitis, the hyperæmic method of Bier is useful in relieving pain and may arrest the disease; when the capsule is distended, it is better to aspirate it if the fluid is serous, or to make a free incision if pus has formed. Sometimes, as in acute arthritis of infants and rarely in pyæmia, the joint is saved by timely interference and free drainage. It often happens, however, that one incision is insufficient even when placed in the most dependent position, and a number of openings are required to open up all the pockets of the synovial membrane, and to ensure free irrigation of the tissues. In the choice of fluid for washing out, it is wise to avoid strong antiseptic solutions, and we employ solutions of perchloride of mercury 1 in 6000, peroxide of hydrogen 1 in 20, boracic acid lotion gr. v.-℥i, or normal saline solution. A vaccine made from the fluid evacuated from the joint, should be injected into the patient.

It is rare nowadays for amputation to be required, yet there must be no hesitation on this point if the patient's life is threatened.

The after-treatment of acute infective arthritis is difficult. Generally, drainage tubes are retained too long. They should not be placed across the joint cavity even at first, but separate pieces of tubing are inserted into each incision, which are shortened rapidly after operation.

When the wounds are healing, gentle movements are begun, and massage and hot-air baths are used so soon as the wound is healed. Much weakness, stiffness, and pain will remain for weeks and months. In fact, recovery of the functions of the articulation only takes place " with and through pain."

Acute Arthritis of Infants, first described by the late Sir Thomas Smith, is an infective condition of a joint, due to a septic epiphysitis, and in some cases to a juxta-epiphysitis as well. It occurs usually in infants under one year, and several joints are sometimes involved simultaneously. Pus forms in the epiphysis, destroys the ossific nucleus, and, perforating the cartilage, penetrates the joint cavity. Strepto- and staphylococci are found in the pus, and they vary in their virulence. Generally the joint or joints are destroyed, and the infant's life is endangered. Early incision is essential, and serum and vaccine are indicated.

Gonorrhœal Arthritis

The means by which the gonococcus reaches the joint is the blood-stream; and when the fluid in the joint is flaky, this organism can be isolated from it, but not always when it is clear, although it can be found in the tissues. The forms assumed by gonorrhœal arthritis are :—(1) Arthralgia, (2) Hydrops, (3) the Sero-fibrinous form, (4) Empyema, (5) Phlegmonous inflammation, and in all cases the clinical picture varies with the pathological changes. It is asserted by Bennecke that the phlegmonous form is the most frequent. This is not our experience.

Ætiology.—With regard to *sex*, of 56 cases observed by C. F. Marshall,[1] 18 were in men and 38 in women. The ages of the men varied from 22 to 54 years, of the women from 15 to 42 years.

As to the *joints* implicated, the knee was affected thirty-one times, the hip eight, the ankle nine, the foot six, the shoulder four, the elbow ten, the wrist six, and the fingers four times. So that in fifty-four patients there were seventy-eight joints affected. Monarticular affections occurred in thirty-nine patients; two joints were affected in eleven patients. Of the thirty-nine monarticular cases, the knee was affected seventeen times, the elbow seven, and the hip seven. In only one patient had the gonorrhœal discharge ceased when the symptoms appeared. In forty of the cases, the onset was sudden and early, and progress was rapid. The effusion from the joint was examined in twenty-seven patients, gonococci having been found eight times. It is evident that the knee-joint is most usually affected.

Clement Lucas [2] reports twenty-three cases of joint disease in infants, following purulent ophthalmia, and he describes two forms of arthritis—one a very acute form, accompanied by much swelling and tenderness, and suggesting suppuration; and the other a subacute synovitis, with effusion.

Symptoms.—1. In the *arthralgic* form several joints are usually affected, and there is little tendency for the pain to shift. It usually remains in the joint or joints first attacked. Such a form of arthralgia is common about the ankle and the small joints of

[1] Cf. C. F. Marshall, *Med. Ann.*, 1900, p. 290; also Bennecke, *Die gonorroeische Gelenkentzündung*, Berlin, 1899.

[2] *Trans. Roy. Med. and Chir. Soc.*, 1899.

the foot, and is frequently followed by a very troublesome type of flat foot. As a rule, when arthralgia makes its appearance, there is an increase or re-appearance of the gleety discharge.[1]

2. The second form in which gonorrhœa affects joints is the *serous*, when *hydrarthrosis* is present. In this variety, which may be monarticular, and is then particularly likely to affect the knee-joint; or polyarticular, when there is a rapid effusion into the joints, it is commonly observed that the onset is sudden, the joints become quickly distended, and the disappearance of the fluid is very gradual.

The changes in the synovial membrane are very slight, and consist of the usual reddening of that membrane, with some thickening of the subsynovial tissue. As a rule the general symptoms are not marked, although a rise of temperature of two or three degrees at night is frequently observed. In occasional instances the patient is very ill, and the temperature rises to 103° or 104°. Very often this form is accompanied by some extra-articular inflammation and involvement of the peri-articular tendons and their sheaths, of ligaments and of fasciæ.

3. The third or *ankylosing* form is generally non-suppurative. It usually comes on very suddenly. It is very painful, and the joint becomes rapidly stiffened. As a rule, there is little fluid in the joint cavity, and the type of inflammation is *sero-fibrinous*. The extra-articular tissues are much affected, and the skin is often red, so that the general effect is to cause much stiffness of the part. In the articular cavity, fibrin is deposited, so that the folds of the synovial membrane adhere together, the capsule is thickened, and the bands of fibrin become organised. Vessels appear in the bands, and invade the cartilages, and they become granular and ultimately eroded. It will therefore be seen that the integrity of the joint is seriously endangered. As the outcome of these changes one of three results may follow. The condition ultimately subsides, leaving the joint more or less stiff for a long period; or fibrous ankylosis may follow, which is permanent, and, in extreme cases, bony ankylosis. When this form affects the spine it becomes absolutely rigid, and the process may extend to the costo-vertebral articulations, thus seriously crippling the breathing powers of the patient.

The sero-fibrinous form of gonorrhœal arthritis is frequently

[1] E. Percy Paton, "Infectious Diseases of Joints," *Clin. Jour.*, May 24 and 31, 1905.

polyarticular, and is very refractory to treatment. It often leads to the most extensive crippling.

4 and 5. The *suppurative* and *phlegmonous* cases are fortunately rare. The onset is usually attended by much pain, swelling, and constitutional disturbance; although my colleague, the late Percy Paton,[1] pointed out that in some of these cases there is practically no constitutional disturbance at all, and he quoted two striking examples. If pus forms, the changes which occur in the joint are identical with those met with in all forms of suppurative arthritis. There is no evidence to show that this most severe form of gonorrhœal arthritis is due to a mixed infection. In the phlegmonous type, severe, often brawny inflammation of the peri-articular tissues is present. As to the existence of the organism in and around the joint, in many cases gonococci can be demonstrated in the granulation tissue of the synovial membrane, even when repeated examination of fluid has failed to show them.[2]

When we meet in adult life and in middle-aged persons with a persistent and intractable monarticular or polyarticular swelling, we should always think of gonorrhœa as an exciting cause, and careful examination should be made for the presence or absence of the primary disorder. This also applies to persistent inflammation of tendon sheaths, bursæ, and to very painful forms of flat foot. The arthritic symptoms usually come on after the third week of the primary disorder, and their onset is sudden, many joints being often affected at once. The extent of inflammation varies, as will be gathered from the description of the types of the disorder given above. The duration of local symptoms is also variable, being slight in the arthralgic and serous forms, and very prolonged in the sero-fibrinous, the purulent, and the pronounced extra-articular types. Muscular spasm sets in early, and the joint is distorted. Considerable wasting of the muscles follows, and the amount of stiffness which is left is variable.

Diagnosis.—This is to be made from acute rheumatism, traumatic synovitis, tubercle, syphilitic arthritis, and osteo-arthritis. The main point is to establish the presence of the primary disorder, and, whenever possible, an examination of the fluid in the joint or

[1] *Op. sup. cit.* p. 93.

[2] Vaquez and Landry (Young's *Orthopedic Surgery*, p. 531) report three cases in which examination of the joint fluid was negative, but ankylosis occurred; yet the examination of a portion of granulation tissue from the synovial membrane, obtained by arthrotomy, showed gonococci to be present in great numbers.

of the granulation tissue should be made, in order to detect the presence of gonococci.

Prognosis.—In the arthralgic and serous forms the outlook is good, but in the sero-fibrinous and suppurative varieties much loss of function, crippling, and considerable ankylosis may be expected. As to the duration of the disease, Northrup[1] states that in 64 cases it lasted one to six weeks; in 54 cases, six weeks to two months; in 77 cases, two months or more, and in 57 cases, the duration was indefinite.

Treatment.—The first thing to be done is to treat the primary disorder. The arthralgia usually subsides quickly, if the patient is placed at rest and suitably dieted and purged. The general indication is rest to the joint, avoiding the danger of too prolonged immobilisation. In the acute stages of the serous and sero-fibrinous varieties, the limb should be kept at rest on a splint, and if there is flexion of the joint, traction or extension is desirable. At the onset, hot or cold applications, accordingly as they relieve pain, and Bier's congestive treatment are useful. So long as the case is running a moderate course, and if the constitutional symptoms are not acute, the local means alluded to, followed by the application of tincture of iodine or ichthyol ointment (40 per cent), or mercurial ointments, are of service. If the symptoms are acute, the effusion is increasing, and it refuses to yield to the above measures, the joint should be carefully aspirated, and careful search made for the gonococcus. If it is found to be present, the joint must be washed out, and the best way to do this is by inserting a large trocar and cannula. The fluid in the joint is evacuated, and the cavity is washed out with 1 in 40 carbolic lotion, or one ounce of 1 per cent protargol injected (Thomson and Miles),[2] and the wound carefully closed. In many cases, in preference to carbolic solution, which damages the superficial layers of the synovial membrane, hot sterile salt solution, or a 1 in 5000 solution of perchloride of mercury, is employed. Should the fluid re-form and the painful symptoms persist, the joint is to be incised, washed out, and drained.

When pus is found to be present, the joint requires immediate opening, the incision being placed so as to drain effectually the cavity, which must be carefully irrigated. In the phlegmonous type of inflammation, especially with much involvement of the extra-articular tissues, free incision into the joint, and prolonged immersion

[1] Quoted by Bradford and Lovett, *Orthopedic Surgery*, 3rd edition, p. 195.

[2] If protargol is injected, the patient should be warned of the reaction which follows.

in a weak solution of biniodide or perchloride of mercury, may result in saving the joint and arresting the onset of partial or complete ankylosis. In the later stages of the disease, especially of the subacute type, our efforts should be directed to promoting the absorption of the effusion and to restoring the movements. For these purposes the hot air bath, cold douching, and carefully regulated passive movements, are of great service. If ankylosis of a partial type is present, and all the acute symptoms have passed away, manipulation of the joint under anæsthesia is advisable, and a gratifying measure of success often follows. When the limb is fixed in the best possible position, it is well not to resort immediately to manipulation under an anæsthetic, but to wait and see what the effects of the massage and gentle passive movements will be. The best restorative measures are carefully regulated functional use of the limb, and apparatus which limits the movement of the part to such a degree as will not occasion discomfort. Vaccination is always of service, if the case is severe or obstinate.

A vaccine may be obtained and the culture made from the affected joint or from the urethra, or a reliable stock-vaccine may be used. As to the dosage, the first dose should be 4 millions, rising gradually to 20 or 30 millions, the intervals at first being of two or three days, and then being increased to a week as the dose increases. In a chronic case much larger doses may be given. The best estimate as to the effect of the injection is formed by careful observation of the clinical signs.

Anti-gonococcal serum, normal horse serum, and anti-streptococcal serum have all been used with a varying measure of success, and a combination of the first named with the vaccine is strongly recommended by Girling-Ball.

Allusion has already been made to gonorrhœal arthritis of infancy, and it assumes a very severe type. Kimball [1] collected 78 cases of gonorrhœal infection in infants. Among them there were ten cases of arthritis. Six died directly from the disease, two died later from exhaustion, and in the two remaining cases recovery seemed doubtful.

Puerperal arthritis, though usually of septic origin, is occasionally due to gonorrhœa, and assumes a severe type.

[1] *New York Med. Rec.*, November 14, 1903.

Pneumococcal Arthritis

Pneumococcal arthritis has been described as primary and secondary. By primary arthritis is meant a pneumococcic inflammation of the joint, when no discoverable lesion of this character elsewhere can be found before the onset of the arthritis. There can be no doubt that infection in these cases takes place through the blood, the diplococci having gained an entrance into the blood-stream through the mucous membranes of the mouth, nose, throat, or ear. In these situations pneumococci can be found in many people (about 20 per cent). An important factor in determining primary pneumococcic arthritis is an injury to the part.

Secondary arthritis is usually met with either during the course or after an attack of lobar or of broncho-pneumonia.

For many of the following remarks we are indebted to an article by Drs. Pasteur and Courtauld.[1]

With reference to the relative frequency of primary and secondary pneumococcic arthritis, of 56 cases recorded in adults, only two were of primary origin. Of 38 cases in children collected by these authors, 6 were primary and 32 secondary. After all, the distinction between primary and secondary infection is a very artificial one so far as the genesis of the disease is concerned, although, clinically, the differentiation is a valuable one. In a secondary arthritis we have to deal with a more or less severe attack of pneumonia with superadded arthritis, a truly virulent state of septicæmia; whereas, in the primary form the amount of blood infection is comparatively small, and the lung symptoms are not present to add to the gravity of the disease. It therefore follows that recovery in primary arthritis is greater than in secondary, the death-rate in the latter not being less than 65 per cent.

Mention has already been made of the influence of injury in determining the incidence of infection by the diplococcus of any particular joint. In the case of a newly-born child the joint attacked has been previously injured during difficult labour, and the experiments of Ausset, Züber, Kasparek, Bezançon and Griffon, are all of interest in this connection.

Nathan Raw found seven instances of arthritis in 817 cases of pneumonia, and Herrick three in 2292. The onset of arthritis is from the fifth to the fourteenth day, and it does not necessarily

[1] "Primary Pneumococcal Arthritis," *Lancet*, June 23, 1906, vol. i. p. 1747.

follow that pulmonary symptoms are present, for in some cases only the joint-lesions were evident, and in other cases arthritis preceded pneumonia. In children, however, the lung is not often affected, and then arthritis is a local expression of general pneumococcic infection.

Pathologically there are three forms: (1) a mild and transient inflammation; (2) a serous form; (3) a purulent form. There may also be a peri-articular form, with secondary invasion of the joint.

The joints most frequently attacked are those of the upper extremity, especially the shoulder, and when the lower limb is implicated it is the knee that usually suffers. In a case under our care at the Evelina Hospital for Children, five joints were seriously affected, and three suppurated. The patient recovered.

According to Cave, suppuration occurred in 27 out of 31 cases, and destruction of the joint followed. The late Percy Paton [1] stated that suppuration may be extra-articular, no pus being found in the joint. Occasionally, the purulent inflammation is not of the usual definite type, and the exudate contains much mucoid material. It has been asserted that this type is very destructive to the integrity of the joint.

The *diagnosis* is made either by the existence of pneumonia, or by examination of the fluid in the joint and the discovery of the pneumococcus.

The *prognosis* is grave. Of 83 cases collected by Herrick and Cave 57 died. As a rule the joint is most extensively disorganised, and ankylosis commonly follows.

With regard to *treatment*, early incision and drainage are absolutely called for, and vaccination should be tried.

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Among the infective forms of arthritis we must allude to *the scarlatinal,* which was formerly described as scarlatinal rheumatism. Fortunately, joint complications of this exanthem are comparatively rare, not being more than 1 to 5 per cent. We do not know for certain if the joints themselves are affected with the scarlatinal virus alone, or if the change is a septic one, proceeding from a mixed infection in the throat.

As a rule the arthritic complication is seen in the third week, although some cases show signs of joint trouble quite early in the disease. Generally, the knee-joint is the usual site of trouble, and Percy Paton pointed out that it has often been injured before the appearance of the trouble in it.

The clinical types of the disease are the arthralgic and arthritic, and the arthritic may be of the fibro-plastic or of the suppurative variety. It is also noteworthy that many such joints subsequently become the sites of tuberculous changes.

In *enteric fever* the bones usually suffer, particularly the spine and the legs; the joints are rarely invaded, even those of the lower extremities. However, Keen has described three forms of arthritis met with in typhoid fever :—

1. Serous arthritis. 2. The typhoid arthritis proper. 3. A form of septic arthritis.

(1) Serous Arthritis occurs at the commencement of the illness, and may be due to the action of the typhoid bacillus itself or to a toxæmia. At the onset, the patient complains of pain in the knees, elbows, or other joints, which swell to a varying degree. The affection may be transient, or the effusion increases, and occasionally suppuration occurs.

(2) Typhoid Arthritis proper.—This occurs during the height of the fever, or less often during the period of defervescence and rarely during convalescence. The onset is characterised by pain and swelling, with infiltration and thickening of the synovial membrane and effusion of fluid into the joint invaded. The course of the disease may be comparatively mild, the attack subsides, and the joints recover completely. In other cases, however, inflammation persists and the joints become ankylosed, or suppuration may

take place. In the monarticular variety the hip is usually involved, and, according to Howard Marsh and Gordon Watson,[1] the attack may end in fibrous ankylosis, or the capsule may become distended by serous effusion, and spontaneous dislocation may follow.

Pathologically, the affection may be due to the direct action of typhoid bacillus on the joint tissues, or it may be part of the general typhoid toxæmia. Sometimes, the fluid withdrawn from the joint has been found to be entirely sterile, and at other times the typhoid bacillus has been demonstrated.

(3) Septic Arthritis.—This is the usual form of septic affection of joints due to the presence of streptococci or staphylococci, which have been absorbed from ulcers or bedsores in the course of the fever. It is a highly dangerous complication and is generally fatal.

Among the remaining forms of infective arthritis we may mention the *erysipelatous* variety, which is due either to direct infection from the neighbouring tissues, or to infection through the blood-stream, also the *influenzal* form. Witzel found that in 225 cases of influenza, in 25 per cent the joints were affected. In most of the cases the complication was a slight one; it was found only in the early stages of the disease, and passed off quickly. It seldom happens that suppuration occurs; when it does, the joint is likely to undergo extensive destruction.

Dysentery is complicated by two varieties of arthritis, one in which clear effusion is present, which quickly disappears; and the other, in which pus forms; and, like some cases of pneumococcic arthritis, pus in dysenteric arthritis is not always followed by extensive destruction of the joint, although stiffness may be left. The onset of the affection is generally at the end of the diarrhœic stage.

The prognosis is usually favourable, and most joints recover.

We mention here *acute rheumatism*, because the view is now being accepted that it is due to the action of a diplococcus. The disease is described in works on "Medicine." It does not, however, come within the scope of this work, but we may add that surgical interference is not required during the acute stage, although the stiffness of the joints (chronic rheumatism) after the attack may necessitate the attention of the surgeon.

To sum up the subject of infective joint diseases, we may say that the clinical forms seen are the arthralgic type, the synovitic

[1] *Diseases of the Joints and Spine*, 3rd edit., 1910, p. 115.

type with effusion, and that type which extends from the synovial membrane to the bones, cartilages, ligaments, peri-articular tissues, and is of the fibro-plastic or the suppurative form; and the prognosis depends largely upon the extent of joint tissue involved.

In carrying out treatment, we are often hindered by the presence of the primary disorder, and the acute prostration and illness to which it gives rise. The arthralgic cases simply need rest, support, and local anodynes. The synovitic cases should be treated locally by hot anodynes and Bier's method, and if they are not followed by diminution in the effusion, then aspiration should be employed, and failing this, the joint may be washed out with antiseptic solutions. Drainage in these instances is to be avoided, because of the granulations which spring up around the tubes, and give rise to fibrous bands in the joint, causing fibrous ankylosis. Suppurative cases should be explored with the aspirator, and freely opened and drained, but the drainage tube should never be passed across the joint for fear of increasing the amount of intra-articular fibrous tissue. The joint should also be placed in that position which ensures the best drainage; and, so soon as pus ceases to issue, the part should be put into the best possible position under an anæsthetic. Appropriate vaccines are to be administered.

As soon as possible, in all cases of infective joint disease, massage and gentle passive movements should be commenced.

CHAPTER V

ACQUIRED AND HEREDITARY SYPHILITIC DISEASE OF THE BONES AND JOINTS

Acquired Syphilis—Local Periostitis—Osteomyelitis and Osteitis—Nodes and Gummata—The Joints—Syphilitic Spine—The Bone and Joint Lesions of Hereditary Syphilis—Treatment.

Acquired Syphilis.—During the primary stage, neuralgic pains are frequently felt about the large joints, especially by those who live in warm and damp climates.[1] In the secondary stage both bones and joints suffer. The bones are frequently painful, particularly at night, and the joints are affected with serous synovitis. They are painful, red, and swollen. The serous effusion may persist, and pass on to chronic hydrops, but the main incidence of syphilis upon the bones and joints is found in the tertiary stage, and takes the forms, in the bones, of local periostitis, osteitis, and osteomyelitis. In the joints, we meet with gummatous synovitis and chondro-arthritis.

Local periostitis is found most commonly on the tibiæ, although any surface of bone lying close to the skin and exposed to injury may be the site of a node. A node is an ill-defined swelling, adherent to the bone, and unless inflammation takes place the skin moves easily over it. It is always tender, and is more painful at night. If the patient be unhealthy, or if the exudation become infected, the node suppurates, discharges part of its contents, and an ulcer is formed with a typical wash-leather base. Beneath the ulcer, the superficial layers of bone are often necrosed. Nodes are frequently seen on the skull, sternum, and other long bones, in addition to the tibiæ.

Osteitis and Osteomyelitis.—Gummatous inflammation may be either localised or diffuse. If it is localised, it may so weaken the bone as to cause spontaneous fracture. More frequently the

[1] D'Arcy Power, *Ency. Med.* vol. xii. p. 24.

syphilitic process causes general sclerosis throughout the bone, so that it is thickened and heavier than usual. As a rule it does not go on to suppuration, and rarely to necrosis, unless the patient's health is bad, or he has been extensively dosed with mercury.

The spongy bones are often affected by syphilitic osteomyelitis, and the bones of the head and face suffer, the nose in particular. Nodes frequently form on the vault of the skull; and suppuration, with necrosis of the entire thickness of bone and perforation, may take place.

The Joints.—The serous synovitis occurring in the secondary stage has been alluded to. In the tertiary stage, gummatous osteitis occurring in the neighbourhood of a joint may set up, first, sympathetic synovitis, and later the gummatous process may extend to the subsynovial capsule and tissue, and give rise to true gummatous synovitis. This closely resembles tuberculous synovitis, but, unlike it, is less prone to suppuration. As Mr. d'Arcy Power points out, however, it may be distinguished from the tuberculous form by the comparative absence of pain, and the readiness with which the patient can use a joint, which is apparently disorganised.

The other form of tertiary joint affection is chondro-arthritis, in which a gummatous process takes place in the articular ends of the bones, and an ulcer forms, separated from the joint by a thin membrane of cartilage.

Acquired Syphilitic Disease of the Spinal Column

Syphilitic disease of the contents of the spinal canal is common, but syphilis of the spinal column itself is rare. Jonathan Hutchinson, Junr., states that tertiary syphilis "has little tendency to attack the vertebræ and short bones of the tarsus and carpus—favourite sites for tuberculous disease"; and that from inherited syphilis "the vertebræ[1] seem curiously exempt." Further, since in many of the recorded cases the diagnosis was perforce based on purely clinical evidence, and bearing in mind the difficulty of excluding tuberculosis with certainty, an element of doubt is introduced. Probably, too, syphilis of the spine is less frequent than formerly, because treatment is adopted earlier and is more efficient.

[1] Jürgens states that a syphilitic periostitis and osteochondritis of the vertebræ is constantly observed in congenital cases. However, as neither marked anatomical changes nor clinical manifestions result, the significance is slight (Wullstein).

The manifestations to be looked for are periostitis, diffuse or localised, gummata and nodes, and caries from softening gummata or from direct extension of a syphilitic pharyngeal ulcer. The last is the most frequent and most important of the spinal conditions due to the disease in question.

Cases of syphilitic caries of the upper cervical vertebræ (Figs. 208, 209) have been related by Astley Cooper, Hilton, William Ogle, Leyden, Ollivier, and others. The symptoms are pains chiefly local, worse at night, when there is nothing to distract the patient's attention; difficulty in breathing and swallowing, due to swelling encroaching on the pharnyx; and

FIG. 208.

FIG. 209.

FIG. 208.—Cervical Caries, occurring in a syphilitic patient under the author's care. For this drawing he is indebted to Mr. G. R. Ward of Westminster Hospital.
FIG. 209.—Back view of same patient as in Fig. 208.

rigidity of the spinal segment—as described elsewhere under tuberculous spondylitis. Deformity is not marked, partly because destruction of the vertebral bodies in this region is easily compensated,[1] and partly because syphilitic destruction is accompanied *pari passu* by formation of new bone in the neighbourhood—in contra-distinction to what happens in Pott's disease. The majority of the cases have been recorded, because of the extrusion of sequestra of striking size, or on account of sudden and speedy death due to fracture-dislocation. Suppuration is more marked in these cases than in syphilitic spondylitis elsewhere, because of the almost inevitable secondary infection. As the dura mater does not form the internal periosteum of the spinal canal,

[1] See vol. ii. p. 86.

nerve symptoms are absent, thus contrasting with cranial lesions. Still, the dura mater may be exposed or even perforated. Hilton [1] noted a specimen in which the disease was situated between the occiput and atlas, and between the atlas and axis. Its probable history was that "the man, to whom it had belonged, had been long the subject of syphilis, had suffered great pain in the neck, and that after eating his dinner his head fell forward upon the table and he died instantly."

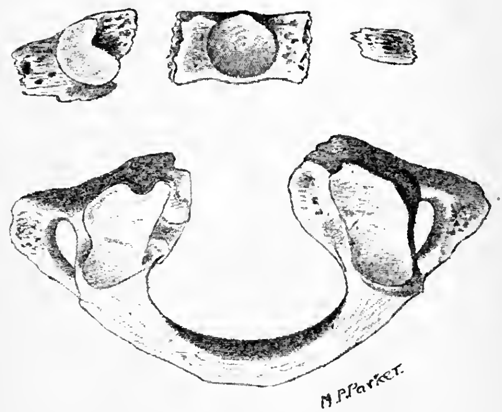


FIG. 210.—Odontoid Articulation of the Atlas, separated by Ulceration. An atlas is placed below, with the corresponding portion broken off, so as to show the relationships of the separated part of the anterior arch. The three fragments were expelled from the mouth during a fit of coughing (Guy's Hospital Museum).

This supposition is rendered more reasonable by such cases as Astley Cooper's, in which sudden death resulted from the fracture of a gummatous odontoid process, with luxation forward of the atlas.[2] Also in Leyden's case, where a woman, whilst beating her son, died suddenly, and the post-mortem revealed fracture of the third cervical vertebra and forward dislocation.[3]

Also the case recorded by Ollivier, in which death rapidly followed on the removal, by the patient herself, of a cardboard collar applied by Dupuytren for cervical disease.[4]

Extrusion of Sequestra.—Wade's patient removed the major portion of the anterior arch of the atlas;[5] Wade also refers to another in which a portion of the margin of the foramen magnum of the occipital bone was extruded together with the anterior arch of the atlas.

Ogle's patient coughed up the fourth cervical body almost entire,

[1] *Rest and Pain*, 3rd ed. p. 111.

[2] Astley Cooper, quoted in *Thèse de Paris*, 1881, p. 41.

[3] "Über einen Fall von syphilitischer Wirbelerkrankung," *Berl. klin. Wochenschr.*, 1889, No. 22.

[4] Ollivier, *Traité de la moelle épinière et de ses maladies*, vol. i. p. 350.

[5] *Med. Chir. Trans.* vol. xxxiii.

together with the intervertebral disc and a portion of the contiguous vertebra.[1]

Syphilitic caries, due to gummatous softening, may also end in sequestrum formation in the dorsal (Fig. 210) region of the spine. Thus Reeves [2] mentions a case of syphilitic caries in a boy under his treatment at the London Hospital, who, it is stated, coughed up portions of the vertebræ which had penetrated the lung.

Abscess formation is infrequent, although in Fournier's case an abscess was present in each psoas muscle. In this case both the cause and actual condition were verified post-mortem. The third, fourth, and fifth lumbar vertebræ were especially affected. Besides the psoas abscesses, the lesions present were denudation of bones, thickening or destruction of the

FIG. 211.—Angular Deformity of the Dorsal Spine, occurring in a patient suffering from Acquired Syphilis (Joachimsthal).

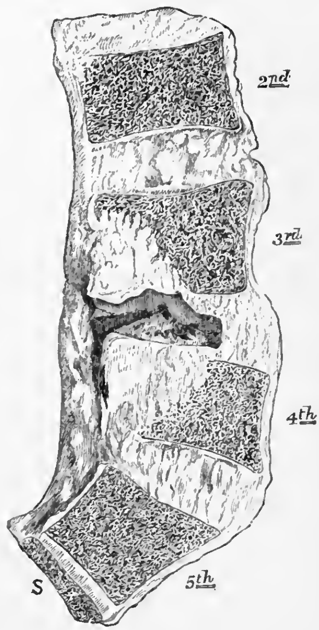


FIG. 212.—Vertical antero-posterior section of the Lumbar Spine, showing Gummatous Deposit in the posterior part of the intervertebral disc between the 3rd and 4th Lumbar Vertebra (after Fournier).

[1] *Med. Chir. Trans.*, 1872. Somewhat similar cases are recorded by Fischer, *Syphilitische Nekrose des Atlas*; Heilung, *Deutsche Zeitschr. f. Clin.* Bd. 22; Beck, *Trans. Ulster Med. Soc.*, 1876; and Teissier, quoted by Nélaton, *Pathologie chirurgicale*, 2nd part. Dura mater exposed and visible, cf. cases by Autenrieth; Levot, *Thèse de Paris*, 1881; Dunlop, *Brit. Med. Journ.*, 1893, vol. ii. p. 1380; Colles, *Pract. Observ. on the Venereal Dis.*

[2] *Op. cit.* p. 133.

periosteal and ligamentous structures, sclerosing osteitis, with caseous and purulent infiltration, almost complete destruction of the intervertebral fibro-cartilages, and a vast cavity in the lumbar column.

Angular deformity, for the reasons given above, is uncommon. Joachimsthal figures such a case;[1] and Howard Marsh records one in which there was considerable increase of the dorsal curve.[2] The author has met with only three cases in which syphilis was probably the cause of the kyphosis. They all improved with appropriate treatment. In no instance, however, has he had an opportunity of verifying his opinion by post-mortem examination.[3]

Undoubtedly, the absorption of a gummatous infiltration may lead to more or less loss of substance, without suppuration, by the process known as caries sicca.

Syphilitic nodes either on the vertebral bodies, in the canal or intervertebral foramina, or on the processes, may give rise to symptoms. Thus Lévot describes displacement forwards of the soft palate; Wullstein, pressure on the œsophagus, calling for gastrostomy; Virchow, pressure on the spinal cord; and Piorry, sciatica due to pressure on the lumbar nerve roots.

Diagnosis.—The signs in general of syphilitic spondylitis are those of tuberculous spondylitis, save that in the latter the tendency to abscess formation is greater, to new bone-formation less, and therefore the deformity is not so limited. Syphilitic spondylitis is a tertiary manifestation of acquired syphilis. These grave spondylitic conditions are seldom met with in congenital cases.

Possibly, the safest plan is to regard every case as tuberculous, then to ask oneself the question, Can it possibly be syphilitic? Of course one may see syphilis in a tuberculous patient, and *vice versa*. The age of the patient, the signs and stage of the syphilitic infection, the Wasserman test, and the reaction to anti-syphilitic treatment are all important points. The last is only "*post hoc*," however, and not conclusive at that. In short, save for the typical cases of extension from the pharynx, differential diagnosis is a matter of probability only. A caries sicca in a syphilitic adult, and yielding to antisyphilitic treatment, is suggestive. The conclusive evidence can only be attained post-mortem; though, fortunately, even the serious cervical cases are less fatal than might have been anticipated.

[1] Joachimsthal's *Handbuch*, Part II. p. 1251. [2] *Ibid.* p. 793.

[3] These cases were seen before Wassermann discovered his "test" for syphilis.

Treatment.—First and foremost comes antisyphilitic treatment—the rest depends on the condition. Spondylitis must be treated on the lines laid down in Pott's disease, support and correction afforded, until it is believed that the process is over, and the newly-formed bone sufficiently strong. Necrosis must be treated on general lines.

The Bone and Joint Lesions in Hereditary Syphilis

Apart from the "triad" of Hutchinson, namely, auditory, ocular, and dental affections, the bone and joint complications in hereditary syphilis are, if not always the most obvious, certainly the most persistent.

The osseous complications are very frequently seen in the cranium, face, and the extremities. They occasionally occur on the clavicle, ribs, and sternum, but we have not met with the disease affecting the spine.

The Cranium.—We are all well acquainted with Parrot's nodes. Extended observation and carefully recorded cases show that the cranial signs may be classified as: (1) Partial or localised, and affecting a segment of the cranium; and (2) general affections of the cranium.

(1) *Partial.*—Partial manifestations are seen on the frontal, the lateral, and posterior parts of the skull, and are frequently associated either with premature or—the opposite condition—delayed closure of the fontanelles. The partial manifestations take the form of bosses, which are most marked in the frontal bones. According to Edouard Fournier, hereditary syphilis may declare itself, so far as the frontal bones are concerned, in three ways:—The whole of the frontal bone may be unduly convex and prominent, giving rise to what is termed in France the *front Olympien,* or as it is sometimes called in this country, the belly-like frontal bone.[1] The more common affection of the frontal bones is an exaggeration of the normal eminences; and a rare form is the keel-shaped frontal bone, in which, in the position of the interfrontal suture, a vertical ridge of bone 1-2 cm. in breadth is developed, whilst the lateral aspects of the bones are flattened.

Other local manifestations of the disease are seen in the familiar enlargements of the parietal eminences, which may exist alone, or in conjunction with enlargement of the frontal eminences.

[1] How much less picturesque we are in our descriptions than the artistic French!

In the latter form we see the characteristic natiform or "hot-cross bun" cranium.

The rarest of all forms of manifestation of hereditary syphilis of the cranium is the occipital enlargement. It appears as an excessive overgrowth of the occipital protuberance.

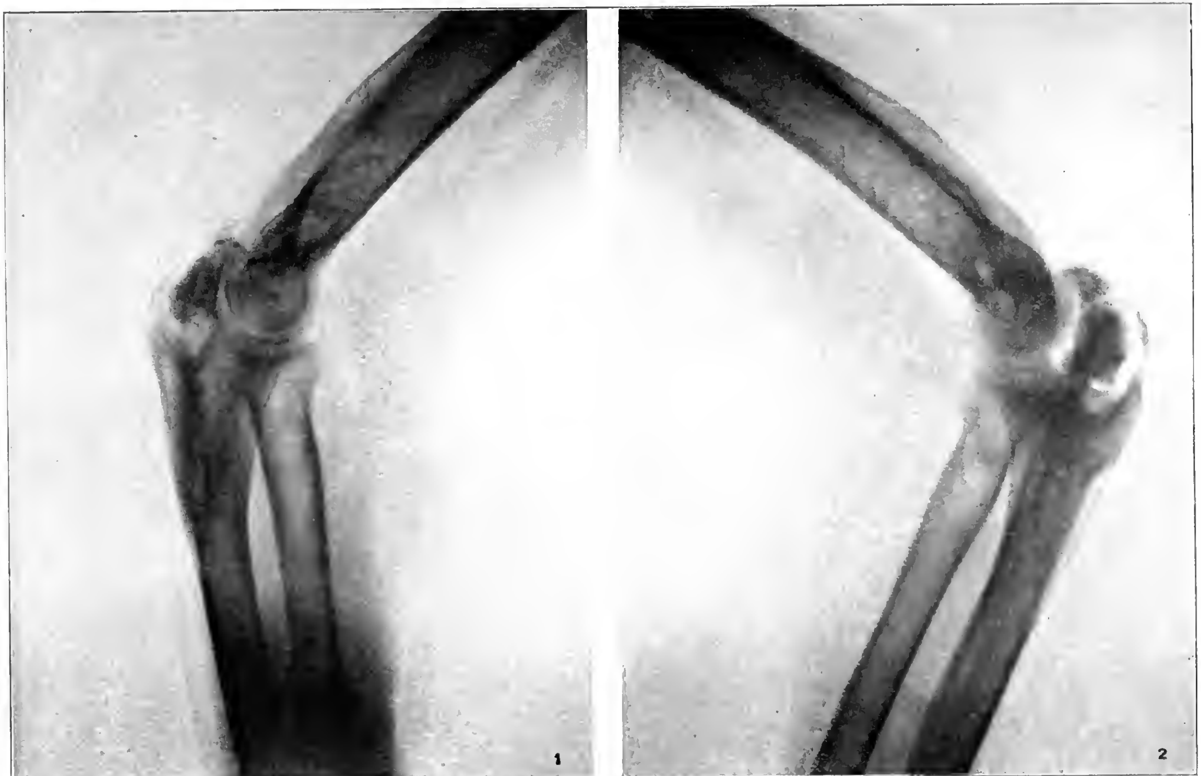
(2) *General.*—They may take the form either of increase or decrease of the normal size of the skull-cap. The globular cranium associated with hydrocephalus [1] is a type of the increased form, and is often difficult to diagnose from rickets with hydrocephalus. In hereditary specific disease it is found that most of the children affected die young, and do not survive until the usual time of the onset of rachitis. Characteristic examples of general decrease in the size of the cranium are seen in some microcephalic children, and Fournier has noticed the constant association of cranial asymmetry with inherited disease.

Of the bones of the face, the nose shows the most characteristic changes. In occasional instances the root of the nose is broadened extremely, and imparts to the patient a leonine aspect. In other cases the course of the disease is destructive, and the bones of the nose become affected, after the appearance of chronic coryza, by purulent discharge, epistaxis, and ozæna. The type of nose varies. In some cases the depression is more marked at the bridge; whilst in other cases destruction has taken place at the extremities of the nasal bones, and there is some loss of the cartilage, hence the nose is tip-tilted, with a deep furrow extending across it at the junction of the cartilages and bone.

With regard to the bones, even beyond the age of puberty, patients affected by hereditary syphilis suffer from chronic pains, which are frequently ascribed either to growing pains or to rheumatism. The pains are felt more often in the legs than in the arms, and particularly about the crest of the tibia. They are exaggerated at night, and are sufficiently severe to keep the patient awake. They often come on in paroxysms, in which distinct crises can be recognised. In many cases they are not associated with any external signs, but in others distinct evidences of chronic osteitis, hypertrophy of large bones, and gummata are found. The pains often last for months or years, and not infrequently their nature escapes diagnosis.

[1] Cf. "Hereditary Syphilis and Cranio-tabes," G. A. Carpenter, *Brit. Jour. Chil. Dis.* vol. v. No. 2, p. 36, and the writer points out that in what may be termed the syphilitic age, cranio-tabes is quite a common occurrence, whilst in the rickety age, from the ninth month onward, the reverse is the case.

PLATE XVI.



Necrosis and Formation of a Sequestrum in the Olecranon Process, due to Congenital Syphilis (Alban Köhler). The patient was aged 17 years, and had suffered from syphilitic dactylitis and squamous syphilides.

To face page 386.

With reference to the other bone lesions they may be classified as—(1) localised thickenings, taking the form of hyperostoses or exostoses; (2) cicatrices adherent to bone; and (3) local deformities.

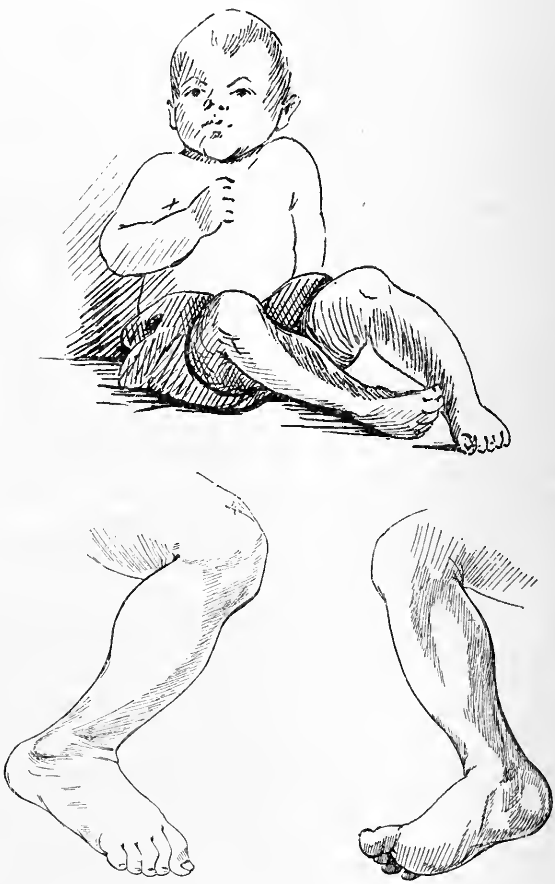
The exostoses are found either in the epiphyses or diaphyses. The epiphysial variety most frequently affects the upper end of the tibia, but it is also seen in the extremities of the radius, the ulna, and at the malleoli. The diaphysial type of bone lesion is best marked in the tibia and the phalanges. In the tibia, the exostosis or hyperostosis may be either localised, and break down into gummata; or, the whole shaft of the bone may be affected, giving rise to a characteristic deformity, which the French call *tibia en lame de sabre* (Fig. 213).

Fig. 213.—Lateral view of Tibiæ, affected by Congenital Syphilitic Osteitis (*Tibia en lame de sabre*).

Joints. — Affections of these structures are usually secondary to those of the bones in the neighbourhood. In some cases of syphilitic epiphysitis the inflammation extends to the joint, and results in simple serous effusion or hydrarthrosis. In other cases the disease may be so extensive as to involve the joint seriously, either by direct continuity or by perforation and irruption of pus into the joint cavity. In older children particularly about the ages of twelve to fourteen, a rarefying osteitis, associated with a deposit of caseous material in the cancellous tissue, affects many bones. The process extends to the articular cartilàges, and results in grooving and pitting, the condition being known as "chondro-arthritis." The signs of the affection are recurring attacks of synovitis, with chronic inflammation of the neighbouring bone. This form of disease is said not to respond to the usual remedies, and is practically incurable; in fact, it may be described as a para-syphilitic manifestation.

Gummatous thickening of the synovial and sub-synovial tissues is not uncommon, and is usually associated with osteo-periostitis and the formation of osteophytes. Partial loss of movement and even complete ankylosis results, with muscular and ligamentous contraction.

It is noteworthy that the manifestations now referred to are usually seen at the larger joints, particularly the shoulder, elbow, and knees. It is a question whether some forms of chronic deforming joint disease, having a very close resemblance to chronic deforming rheumatism occurring in young people, are not manifestations



Right Leg. Outer Side. Left Leg. Inner Side.

FIG. 214.—Congenital Syphilis, with marked Curvature of the Tibiæ, from a male infant aged 13 months, seen at the Evelina Hospital for Children.

of hereditary disease. It is certain that, if careful examination is made, some of these children show unequivocal signs of syphilis.

Whilst the general surgeon, on the one hand, is apt to overlook the more remote sequelæ of the affection, and often fails to trace conditions to their origin; on the other hand, syphilographers are prone to assume that any disease occurring in a patient congenitally afflicted must necessarily be specific in origin. Therefore some of the inferences and statements of these latter observers must be received with considerable caution and even scepticism.

Syphilitic Epiphysitis (Pseudo-Paralysis).—Before the age of twelve months [1] the typical bone-lesion is an osteo-chondritis, which affects the epiphysial lines, either in the form of small hard tumours or of general enlargements resembling those of rickets (Fig. 214). The epiphysis most usually affected is that of the lower end of the femur, and next to that the upper end of the humerus (Fig. 215). Inasmuch as a good deal of the growth of the lower and upper limbs depends upon the integrity of these epiphyses, any extensive interference with or destruction of them is followed by shortening of the limbs. In syphilitic epiphysitis, there occurs an increase in the number of the cartilage cells, resulting in irregular distribution, and followed by premature calcification. Proliferation of soft tissues results in pressure on the circulation, so that the epiphysial cartilage is deprived of part of its nutrition. As the soft cells increase in number, they undergo a degenerative process which is evident to the naked eye as a zone of hard dry yellow material lying next to the shaft of the bone. The next stage consists of a fine line of separation, visible to the naked eye, on the shaft side of the epiphysis. Either as the result of trauma at this stage, or on account of the absence of treatment, the fine line may extend completely across the epiphysial junction, until the epiphysis is entirely separated from the shaft, becomes a sequestrum, and suppuration ensues. Concurrently with these changes, the adjacent joint becomes affected, in the early stages, by serous synovitis. In the later stages, pus, formed outside the joint, may penetrate the capsule, and cause destruction of the articulation.

Symptoms.—The characteristic signs of the disorder are the age at which it is seen, usually before the onset of rickets, and the powerlessness of the affected limb, which was characterised by Parrot as "syphilitic pseudo-paralysis." If the disease is allowed to progress, the part becomes swollen, and then tender. Fluctuation follows, and pus may burst through the skin. When the epiphysis

[1] G. A. Carpenter, *loc. sup. cit.* p. 42, records a case occurring in a child aged 17 months (*i.e.* in the rickety age) in which both elbows were involved. His article on "Congenital Syphilis in Infants" deserves very careful attention. It gives the experiences of a most competent observer, whose recent death we deeply deplore.

has been completely separated, fracture occurs, and the helplessness of the limb is more apparent.

Syphilitic Dactylitis.—Children are the subjects of syphilitic dactylitis, which is much less common than tuberculous. It is said to affect the metacarpal or the metatarsal bones more frequently than the phalanges, whereas the reverse is the case in tubercle. The affection begins in one of two situations, either in the subcutaneous tissue

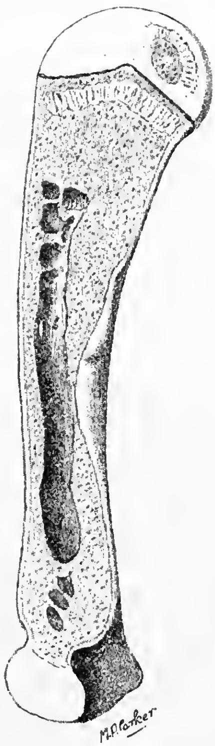


Fig. 215. — Congenital Syphilitic Epiphysitis (Syphilitic Pseudo-Paralysis) affecting the Upper Epiphysis of the Humerus. Note the line of commencing separation of the epiphysial cartilage (Guy's Hospital Museum).

Fig. 216.—Suppurative Congenital Syphilitic Epiphysitis at the Lower End of the Radius, in an infant aged 1 month, seen by the author at the Evelina Hospital for Children. The child died shortly after the drawing was made, and the epiphysis was found lying loose in a purulent cavity.

or in the interior of the bones, as an osteomyelitis. As a rule it does not break down unless the tissues become infected with organisms.

Other Bony Lesions in Hereditary Syphilis. — Later in childhood, nodes and gummata develop on the skull, tibiæ, and beneath the mucous membrane of the mouth and nose, and often cause extensive destruction of parts. About the time that the corneal changes appear, hereditary specific arthritis is met with. It usually takes the form of symmetrical synovitis, which improves rapidly under treatment. However, at puberty a very severe form of arthritis is met with, though fortunately it is rare. A rarefying osteitis commences in the cancellous tissue of the ends of the bones and in the articular cartilages, with the result that a deposit of caseating material is seen in the cancellous tissue, whilst the cartilage overlying it is irregularly pitted and grooved. The disease has received the name of chondro-arthritis; and it is very destructive to the implicated joints.

Syphilitic Curvature of the Tibiæ[1]

This variety of curvature is met with late in hereditary syphilis, and occasionally in acquired syphilis.[2] The conditions described are not peculiar to the tibiæ, but are most frequent and characteristic in those bones.

Chronic acquired syphilitic osteo-periostitis was met with by Fournier in a series of 193 cases, in 91 of which the tibiæ were affected, in 22 the ulna, in 15 the radius, in 16 the cranium, in 12 the humerus, and other bones in 37.

Fig. 217.—Congenital Syphilitic Curvature of the Tibia.

In the case of the tibiæ, nodes may form at any part of the bony shaft in hereditary syphilis, and general osteitis extending nearly the whole length of the bone is not uncommon in the tibia, fibula, and bones of the forearm. The affection is frequently symmetrical, and most of the cases are seen between the ages of five and

[1] Or *Osteitis Deformans Syphilitica* (Hutchinson and Fournier).

[2] Tertiary periostitic nodes may give rise to somewhat similar appearances.

fifteen years. We have met with eleven cases during the last fifteen years. The following are the descriptions of two cases which came before us at the Royal National Orthopædic Hospital. The appearances are seen in Figs. 213, 217.

CASE 15. *Hereditary Syphilitic Curvature of the Tibia.*—M. E., aged 5 years, was seen in October 1892. There are five children in the family, and this is the second child. The mother has had no miscarriages, but she suffered from a rash after the birth of the patient. The child had snuffles when born, and red spots on the body up to three years of age.

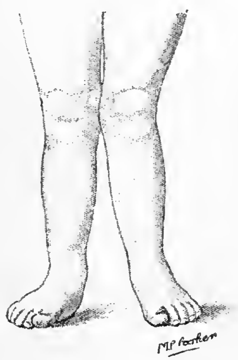


FIG. 218.—Antero-posterior view of legs in Fig. 213.

There is now a peculiar earthy pallor, with a high arched palate, and the scoring around the mouth, associated with the congenital taint. The next child has also shown signs of congenital syphilis.

The deformity is seen in Figs. 213 and 217. On looking at the lower limbs from the front very little abnormality is observed, except that there is some genu valgum. A lateral view, however, shows a remarkable anterior curvature of both legs, which is nearly symmetrical, and affects the middle of the shafts of the bones. The crests of the tibiæ are very rounded, and the internal and external surfaces of the bones are convex. The curvature in both cases is strictly anterior, and not antero-lateral.

CASE 16. *Hereditary Syphilitic Curve of the Tibia.*—A. J. S., aged 6 years, was seen in February 1896. The mother has had six children and two miscarriages, which occurred at the seventh month of pregnancy. Of the six children two died in infancy, but the cause of death is unknown. There is no history in this patient of spots or of sores round the mouth, and no sign of keratitis.

The child is seen to be fairly healthy-looking. On looking at the lower limbs the shaft of the right tibia is seen to be thickened for six inches. The crest is ill-defined, and the lateral surfaces are rounded. The leg is hot and red, and there is an anterior, but no lateral, curvature. The left leg is affected to a less degree than the right, which has been tender for the past eight or nine months, and the patient is unable to walk. The teeth are defective, dome-shaped, and irregular.

After taking grey powder for three weeks, the nodes and tenderness disappeared, and the forward curvature in both legs decreased.

We are therefore dealing in these cases, which have been quoted, with a diffused syphilitic osteo-periostitis.

As to the *diagnosis* from rachitic curvature, the following table will serve to show the points of contrast :—

	Rachitic Curves.	*Syphilitic Curves.*
Age	Generally under three years of age	Occur up to fifteen years of age
History	Signs of rickets present	Syphilis in parents, and other signs of hereditary syphilis in child
Direction of Curvature	Antero - external or antero-internal	Generally purely anterior.[1] (*Tibia en lame de sabre*)
Position of Curve	Generally in upper or lower third	In middle of shaft
Crest of Tibia	Sharp	Smooth and rounded
Surfaces of Tibia	Flat or concave	Convex

It is to be noted that in some cases the affected bone is actually lengthened, due to inflammatory stimulation of the epiphysial line.[2]

The points given in the table enable a distinction to be made between the forms of tibial curvature in rickets and hereditary syphilis. In the acquired form the affection is a localised swelling or node rather than a curvature, and is rarely symmetrical.

The treatment is anti-syphilitic. The patient should be placed at rest. Splints are rarely called for, except to keep an inflamed part quiet. In very rare cases, wedge-shaped osteotomy may be called for, as in the case of Moses.[3] The patient was twenty-four years old, and the tibiæ began to curve when he was ten years old.

Treatment in General.—In adults, mercury in its various forms is invaluable in the secondary stages; and mercury combined with the iodides, or the iodides with iron, is called for in children. It often happens that a local lesion in adults, which has suppurated, will not heal up under constitutional treatment, and in these cases it is necessary to scrape the gummatous material from the bone; and, where the disease does not yield to any of these measures, Zittmann's regimen should be followed out.[4] In hereditary syphilitic epiphysitis, a most striking point is the way in which the lesion yields to mercury, given in the form of grey powder. Even if separation of the epiphysis has occurred, it will unite again; and unless the condition has proceeded too far, when the pus is evacu-

[1] Holt's *Diseases of Children*, p. 919.

[2] Joachimsthal's *Handbk. der orth. Chir.* Pt. i. p. 103.

[3] *Beitrag z. Wesen der Kongenitalen Syphilitischen*, "Tibia en lame de sabre," Diss., Königsberg, 1904.

[4] For details see *Ency. Med.* vol. xii. p. 22.

ated and liberal doses of mercury are given, necrosis may be prevented. When the nasal bones are affected, unless treatment is begun early, permanent flattening of the bones is sure to follow; nevertheless nearly all cases of hereditary syphilitic arthritis yield to mercury, except that particularly destructive form, chondro-arthritis.

SECTION VII

RICKETS AND ITS DEFORMITIES

CHAPTER I

RICKETS AND RICKETY DEFORMITIES

Definition—Varieties, Infantile, Late, Recrudescent, Senile, "Scurvy"—Ætiology—Pathology—Symptoms—Diagnosis—Treatment—Deformities of the Skull, Spine, Chest, Arms, and Legs.

Synonyms—Latin, *Rhachitis, Morbus Anglicus, Articuli Duplicati*; German, *Die englische Krankheit, Doppelglieder, Zwiewuchs*; French, *Rachitisme, Maladie anglaise*; Italian, *Rachitide.*

Definition.—A constitutional disorder, which occurs chiefly in children, is associated with malnutrition, and manifests itself largely by changes in the bones.

Rickets is sometimes a long-continued disorder, with occasional manifestations of varying degree.

A description of all the aspects of rickets is out of place here, for the surgeon is called upon to deal with rhachitic deformity as *un fait accompli*, but it is necessary to give briefly the main points of the disease before discussing the associated deformities.

Varieties.—Those which are referred to by various authors are: fœtal, congenital, infantile, recrudescent, rickets of adolescence, late rickets, senile and "scurvy rickets."

The occurrence of *fœtal* rickets is as yet not proven. There is no *prima facie* evidence against it. Its existence has not been sufficiently substantiated, but, if congenital rickets is accepted as a distinct entity, so also must fœtal rickets be.

As to the existence of *congenital* rickets, Virchow[1] believed in it, and cases have been brought forward by Shattock,[2] Henoch, and others.[3] The recorded cases, however, are rare, and many of them might be more properly included under achondroplasia or chondrodystrophia fœtalis, or some other conditions associated with types of dwarfism. The opportunities of verifying, *post-mortem*, the

[1] *Arch.* Band v., 1853. [2] *Path. Soc. Trans.*, 1881.
[3] T. C. Railton, *B.M.J.*, June 16, 1894.

diagnosis of a condition, which is at once very rare and non-fatal, are few and far between. Monti[1] reports Freda as finding on only one occasion definite clinical signs of rickets among 500 newly-born children, unless the presence of one symptom only, cranio-tabes, is to be taken as evidence of the disease; syphilographers, however, may say that the case was syphilitic. Escher[2] has not met with it at all, either clinically or *post-mortem*, in his observations at the Frauenklinik in Berne.

FIG. 219.—Infantile Rickets (Joachimsthal).

The *infantile* form (Fig. 219) affords the most typical instances of the disease. The incidence of the disease is between the sixth month and the end of the second year, generally between the twelfth and eighteenth months. Its occurrence at the normal period of first dentition may be purely accidental; in fact these periods do not always coincide, for very often when severe rickets is present dentition is delayed; nor is the florid stage of the disorder

[1] "Rachitis," *Kinderheilk. in einziger Darstellungen*, Heft 2, 1900.
[2] "Zur Frage der angeborenen Rachitis," *Jahrb. f. Kinderheilk. Naturfor.* Band lvi.

regularly synchronous with the period of most active growth, which is from three to five years of age.

W. J. Littl[1] stated that true rickets is the only disease which proceeds to eburnation, with arrested growth in length; whilst the width and the density of the bones are often increased, so that they may weigh twice as much as normally. According to him the final stage of rickets is reached about the age of

FIG. 220.—Rickets in early childhood (Joachimsthal).

five years, the disease never returning after that time, although the deformity remains. This agrees well with the history of the cases as usually met with, but many observers do not agree with that writer on the question of recrudescence. Some are firmly of opinion that it re-appears from time to time, and occasionally cases are met with in which obvious rhachitic deformity comes on in adolescence, or even in early adult life.[2] We are then faced by two possibilities, as pointed out long ago by Ollier, either that we

[1] Holmes' *System of Surgery*, 3rd ed.

[2] Duplay's case was aged 17 years, *Gaz. des hôp.*, 1891, p. 1337.

are dealing with infantile rickets, which has failed to reach its final stage—Ollier's *Rachitisme tardif* or *late rickets*—or else that rickets is a disease which may start after early childhood.

Late or recrudescent rickets has been dealt with by Dedeyer and Ollier.[1] Drewitt in 1880 showed at the Pathological Society a case of active rickets in a boy aged ten years, the diagnosis being subsequently verified *post-mortem.* Clutton[2] reported the onset of rhachitic deformity in a girl aged between ten and eleven years. The dentition had been retarded, and she did not walk until she was three and half years old. He also reported a case of Bernard Pitts', in which the deformity came on at twelve years of age (Fig. 221). Edmund Cautley[3] noted a case in a girl aged eleven years. The child suffered from rickets at the age of four, which became recrudescent when she was ten years old. In two cases recorded by Barlow and Berry,[4] the diagnosis was verified *post-mortem.* Robert Jones showed a patient at the Liverpool Medical Institute,[5] and cases have been recorded by others.[6]

FIG. 221.—Late Rickets in a girl aged 12 years (H. H. Clutton, by permission of Messrs. Cassell and Co.).

Recrudescent, late, secondary, or protracted rickets, then, although rare, is occasionally met with. If, however, we use the term "recrudescent," some of the clinical signs, due to rickets of infancy, should be present in the case, and they are. Still, the existence of rhachitis in adolescents (if by this term we mean rickets originating about puberty in young people), free from any previous taint of the affection, is denied by many.

There is no *prima facie* reason against it. At this time the

[1] Sir William Jenner (*Med. Times and Gaz.* vol. i., 1860) referred to rickets coming on in a girl aged 19 years.

[2] *St. Thomas's Hosp. Rep.*, 1884, p. 103.

[3] *B.M.J.*, Jan. 4, 1896; Cautley also refers to articles by Ransford (*B.M.J.*, 1887, vol. i. p. 1213), and Palm (*Prac.* vol. xlv., 1890, pp. 275-320).

[4] Keatinge's *Cyclopædia of Dis. of Children*, vol. ii. p. 225.

[5] *B.M.J.*, February 7, 1896, p. 341.

[6] R. Hutchison (*British Journ. of Children's Dis.* vol. ii. p. 222); R. W. Marsden (*ibid.* p. 565); also E. Roos: "Über späte Rhachitis," *Zeitschr. f. klin. Med.* Band xlviii. Hefte 1 and 2, 1903; also Rötter and Lauenstein (*Arch. f. klin. Chir.* Band xl., 1890.)

growth of the long bones has again become very active after a period of comparative quiescence, and if errors of diet exist, manifestations of rickets may reasonably be expected. Experience teaches, however, that cases free from early rhachitic history, yet showing anything like the generalised epiphysial enlargements of the active stage of typical rickets, are not often met with. But, granted, for example, that the bones in genu valgum, commencing in an adolescent, show typical rickety signs, and are the only rhachitic manifestations in the patient, all we can say is that he may or may not have been the subject of infantile rickets; and that if he were, the affection was not sufficiently severe to leave its impression upon him. However, many authors [1] maintain that if the liability to protracted rickets during the whole growing period is accepted, the liability to the onset of rickets during the same period must be granted. Kirmisson holds this view, and records interesting cases.[2]

The researches of Mikulicz on the nature of the pathological processes in genu valgum point the same way, and M'Ewen's views support him. Perhaps, the fairest statement which can be made at present is that, although the cessation of the rhachitic process may occasionally be delayed to later childhood or adolescence, the primary onset of the disease after infancy is still *sub judice.* Certainly we are not able to diagnose rickets from the presence of a single local deformity, such as incurvation of the neck of the femur,[3] and the significance of the association of albuminuria and late rhachitic manifestations [4] is obscure.

Senile rickets, alluded to by Reeves, is probably osteomalacia. The conception of rickets, occurring after ossification is completed, is impossible on pathological grounds.

Scurvy rickets has been thought by some to be scurvy, by others rickets, and by yet others to be infantile scurvy, occurring in a rhachitic child. It is known as Barlow's disease. The main symptoms are stiffness of the limbs and loss of movement, subperiosteal or intra-muscular extravasations of blood, purpuric spots on the skin, spongy gums, hæmorrhage from the kidneys and spontaneous fractures, occurring in a child from six to twelve months of

[1] Karewski, *Die chirurgischen Krankheiten des Kinderaltes,* Stuttgart, 1894; and E. Roos, already quoted.

[2] *Les Difformités acquises,* p. 216. He says that in one of his cases, in which deformity appeared at eleven years of age, "c'est qu'il n'y a jamais eu chez cette jeune fille de rachitique de la première enfance."

[3] C. B. Keetley, *Illus. Med. News,* Sept. 1888; and *Ann. of Surg.* vol. ii. p. 308.

[4] Lucas, *Lancet,* June 9, 1893.

age. The child becomes thin, has a waxy complexion, and shows all the signs of malnutrition. The swelling of the limbs, the tenderness of the bones, and the loss of power, have caused this affection to be mistaken for acute periostitis and osteomyelitis. The absence of fever and of pyrexial symptoms should at once suffice to distinguish the affections.

Rickets and infantile scurvy may co-exist,[1] and in about half the cases of infantile scurvy, signs of rickets will be found. The rickets may be very slight, and bear no relation to the severity of the scurvy, whilst the great bulk of the cases of rickets show no sign of scurvy whatsoever. Further, the history of Barlow's disease, as illustrated by the rapid cure under appropriate treatment, is quite different from that of rickets.[2] It is obvious, therefore, that scurvy rickets is no more an entity than syphilitic measles. It is scurvy and scurvy alone.

Ætiology.—Heredity plays no part in the production of rickets, nor does syphilis,[3] save indirectly by lowering the general health.[4]

[1] Holt states (*Diseases of Infancy and Childhood*, 3rd ed. p. 249) that the American Pediatric Society investigated in 1898, 379 cases of infantile scurvy. "In 340 of these cases the association of rickets was specially inquired into. In 45 per cent rickets was present, and absent in 55 per cent, thus showing definitely that rickets and infantile scurvy can and do co-exist." The most striking characteristics of scurvy, namely, the tendency to hæmorrhage and the prompt curability of the disease by fresh food and fruit juices, have no counterpart in rickets.

[2] According to G. F. Still, "Infantile Scurvy," *Brit. Med. Journ.*, July 28, 1906, the cause of infantile scurvy is artificial feeding on patent and Pasteurised foods. Fresh milk is only mildly antiscorbutic, raw meat juice and fruit juice are more so, but potato-cream is best of all. Still says that "potato-cream is prepared by boiling or steaming in the ordinary way, with care to obtain a floury potato; the outer floury portion is then scraped off and beaten up thoroughly with enough milk to make a smooth cream, sufficiently thick to pour out of a jug rather heavily, the proportion being two large teaspoonfuls of scraped potato to one ounce of milk. Of this cream one and a half to two teaspoonfuls are given three or four times daily. After two or three weeks the dose of this should be gradually reduced, and omitted altogether within four weeks from the commencement of the treatment. Under antiscorbutic diet the tenderness and pain on movement is usually appreciably less in forty-eight hours, and I would lay it down as a rule that if proper antiscorbutic diet has produced no definite improvement within four days the diagnosis of scurvy should be questioned." See also Barlow, *Med. Chir. Soc. Trans.* vol. lxvi. p. 159; *Lancet*, vol. ii., 1894, p. 1075; also Cheadle, *Lancet*, vol. ii., 1878, p. 657, and vol. ii., 1882, p. 48.

[3] It was Parrott who taught that "la syphilis qui dans son immense processus englobe le rachitis," which opinion later, however, he retracted. Cf. Carpenter, *Brit. Journ. Chil. Dis.* vol. v. No. 2, p. 41, "Syphilis as a Rickets-producer."

[4] Tuberculosis is thought by some to predispose to rickets. Others are inclined to believe that rickets is protective against tubercle. Probably both statements are incorrect. Even tuberculous diarrhœa does not specially predispose to rickets, whilst the enlargement of the lymphatic glands often seen in rickets is not necessarily tuber-

The younger children of a numerous and rapidly begotten family are very likely to suffer, perhaps on account of the deterioration of the mother's health, perhaps because conditions arise adverse to the careful feeding and hygiene of the child. Other predisposing causes are the absence of fresh air and sunlight. Thus it is rare in Southern Italy, where the conditions of life are notoriously hard; yet Italians from that part of their country, settled in temperate climates, suffer severely from rickets; and negroes transplanted to northern countries are affected, whilst in their natural habitat rickets is not particularly common (Hirsch, Baginsky). Holt is inclined to see a racial peculiarity in the extreme susceptibility of negroes and Italians dwelling in New York; and the fact that it is very common in the entirely breast-fed infants of those races, in their altered circumstances, lends colour to this view; but environment counts for more than race.[1]

The racial factor, then, is of little weight. The disease is especially prevalent in large and manufacturing towns. It is common in London, Glasgow, and the towns of South Lancashire, New York, Lyons, Marseilles, Berlin, and Milan. It is said to be rare in sub-Arctic regions, such as South Greenland, Iceland, and Scandinavia, whilst the gipsy children of Hungary and Spain are reported to be almost exempt.[2] Whilst environment counts for more than race, the former is still only of secondary importance.

The *only factor* which is anything like constant is the food factor.[3] Experiments show that the diet which causes rickets is one containing too much starch and too little fat. It must be remembered that the diastatic ferment is absent from the submaxillary glands and pancreas in the early months of life. It is secreted later in small amount only, and the functions of these glands

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culous. Although rickets and the vague condition known as marasmus may coincide, they are not essentially connected. Rickety children are often fat, rosy, and apparently well nourished. Some are flat-footed and pale, and more rarely some are wasted.

[1] Whilst rickets is rare in Southern Italy, yet it is common in the large towns of the plains of Lombardy. It is widely spread amongst races of very different ethnological characteristics, and is not limited to the human species at all. Guérin (*Trans. Inter. Med. Congress*, 1881) produced typical rickets in puppies by feeding them on a meat diet for four to five months, while other animals of the same litter were suckled and remained healthy. Cf. also Dick (*Path. Soc. Trans.* vol. xiv. p. 289); and, since then, it has been observed in young animals of various species, including lions and monkeys, and even in birds.

[2] Baginsky und Bernhardt, "Rhachitis," *Eulenburg's Encyclopædia*, 3. Auflage, 1889.

[3] Cheadle, Discussion at British Medical Association, August 1888.

are not properly established until about the age of sixteen months. However, the mere presence of starch does not cause rickets, since the disease is frequently met with in purely breast-fed infants,[1] and can be produced in young animals by feeding on meat only. That is, the disease may be associated with a dietary free from starch. The importance of the excess of starch in the diet lies in this fact, that in many artificial foods it is utilised to make up for the deficiency in fats. The amount of fat required by young infants is surprisingly large. A child under one and a half years of age requires as much fat daily as its mother, and two-thirds as much as its father.[2] At the Zoological Gardens, London, young animals of various species became weak and rickety, and many died. They were being fed on the same varieties of food as their parents. Thus, young lions were being given lean horseflesh, young bears biscuits and rice, young monkeys fruit and bananas. On the advice of Bland-Sutton, milk, powdered bone, and cod-liver oil were added to the diet, with the best results. Such experiments, and the clinical results of adding a sufficiency of fat to the dietary of rhachitic children, render a searching examination of the various theories,[3] mainly based on preconceived ideas as to the part played in metabolism by the lime salts, quite unnecessary. The insoluble inorganic bases of the powdered bone given to young animals could have played no part in the result, since they are not absorbed. In association with the rhachitis of breast-fed infants, the variation of the fat constituents of human milk has been commented upon.[4] The cause of rickets is the absence of fat from the diet; or else, if present, failure to assimilate this constituent, owing to defective digestion.

Pathology.—In rickets, characteristic changes are seen in the growing bones. They are due to an over-production of the osteoblastic elements, the proliferating cartilage, the inner layer of the periosteum, and of the medullary tissue. Hyperæmia is so

[1] Especially in children who are born late in a family, in cases of too prolonged lactation, and where lactation and pregnancy overlap (A. Dingwall-Fordyce, *Brit. Med. Jour.*, April 28, 1906).

[2] T. H. Sanderson Wells, *B.M.J.*, July 8, 1905.

[3] The connection between late rickets and pathological conditions of the thyroid, if existent, as suggested by certain French writers, is as yet obscure. Joachimsthal, *Handbuch d. orth. Chir.*, 1904, vol. i. p. 72; also Hébert, *Rev. d. orth.*, Nov. 1, 1905, p. 543.

[4] Engel, *Zeitschr. f. physiol. Chem.* vol. xl., 1905; Dingwall-Fordyce, *op. sup. cit.*; Sharples and Darling, *Boston Med. and Surg. Jour.*, 1903, p. 148; Reyher, *Jahrb. f. Kinderheilk.* 3 F. xi. 4, 1905.

PLATE XVII.

FIG. 1.

FIG. 2.

Illustrating Mr. E. Muirhead Little's case of Adolescent Rickets and the Cupping of the Ends of the Diaphyses (*Clin. Soc. Trans.* vol. xl. p. 1). Radiograms of the wrists of a girl, aged 17 years. The cupping is less marked than in infantile rickets, and the epiphysial line is more blurred (E. Muirhead Little).

To face page 405.

marked that some observers[1] have regarded the condition as inflammatory.

In a longitudinal section of a normal ossifying bone, the various zones, namely, the advancing ossification, the calcification of the cartilaginous matrix, and the proliferation and columnar arrangement of the cartilage cells, are definitely and even abruptly marked off from each other. The line of demarcation between the blue translucent tint of proliferating cartilage and the opaque yellowish tint of that in which the lime salts are being deposited is quite distinct. So too is the transition from the calcifying to the ossifying layer. But, in a rickety bone this orderly arrangement is lost, the ossifying process being in advance at one place, and in another lagging behind.

The deposition of the lime salts in the cartilaginous matrix is deficient and irregular. The most marked change of all, however, is the enormous increase of the proliferating cartilage cell-zone. In a longitudinal section this disorderly appearance is obvious microscopically. Under the microscope, patches of ossifying bone will be seen cut off in the proliferating zone, and ossification is of an imperfect or osteoid character. In other parts of the field, islets of proliferating cartilage cells will be met with, surrounded by newly-formed bone. That is, processes, which should be at different levels and in order, are taking place at one spot simultaneously and in disorder. The osteoid tissue which is formed consists of true bone, so far as the organic structure is concerned, but the deposit of lime salts is deficient.

The whole epiphysial junction is enlarged, swollen, and soft. The depth of the growing line from above downwards may be four or five times greater than normal, and its width from side to side is increased, giving rise to those enlargements in rickets so readily felt wherever the ossifying cartilages approach the surface. The epiphysis itself is also enlarged, and the ossifying centres are more diffuse than normal. My colleague, Mr. E. Muirhead Little (*Clin. Soc. Trans.* vol. xl. p. 1), has drawn attention to the cupping of the epiphyses of the long bones in a case of late rickets. The radiograms of the case are re-produced here by his permission (Pl. XVII.). This cupped appearance is noteworthy in this case of late rickets, as it is also characteristic of infantile rhachitis, especially when it affects the lower ends of the radius and ulna.

As we know, bones grow in length by ossification at the

[1] Kassowitz, *Die normale Ossification u. Rhachitis*, Wien, 1885.

epiphysial lines, and in circumference by deposition of bone subperiosteally. In rickets the periosteum is also affected. Cell proliferation of the inner or osteoblastic layer is excessive, with the result that a considerable quantity of spongy osteoid bone is laid down. If these deposits happen to be more or less localised on the bone, they are spoken of as rhachitic osteophytes. Rickety bones are hyperæmic and deficient in organic constituents, the proportions of one-third of organic to two-thirds of inorganic material found in normal bones being reversed in severe cases. The percentage of ash may even fall as low as 19, so that these bones are soft and flexible. Further, not only is there a loss in length, due to the arrest of growth for a time, while the rickets is acute, but the rate of growth may be slowed by eburnation. The total dwarfing caused by rickets must in any given case be a matter of conjecture, yet in extreme cases it may be sufficient to deprive the individual of one-third the normal height. The arrest of growth is most marked in those localities where it should be normally most active at the time, when the rhachitic process is most acute. Thus very early rickets is shown by changes in the cranium and beading of the ribs, and rickets, occurring somewhat later, by temporary arrest of growth in the lower extremities. The results are that, in addition to the total dwarfing, there is more or less disproportion in the skeleton, and the femur may show a shortening of one-fourth of its normal length.[1]

FIG. 222.—A typically rickety child, with deformity of the chest and prominent abdomen.

In addition to being shortened, the bones are, on account of the bulky deposit of osteoid material beneath the periosteum, too thick; nevertheless they are very liable to green-stick fracture,[2] since the bone is soft and weakened. The bone becomes less able to resist

[1] Sir G. M. Humphry, quoted in the article on "Rickets" by Makins in Treves' *System of Surgery*.

[2] H. O. Feiss, *Amer. Jour. of Orth. Chir.*, January 1896, gives skiagrams of a case of spontaneous fracture in rickets, with displacement, without appreciable callus,

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 1.—Radiogram of the Hand of a Healthy Child, aged 6 years (Alban Köhler). Note the clear definition of the epiphysial lines, especially of the radius and ulna, the spindle shape of the metacarpal bones and the phalanges, and the healthy ossific material of the shafts of the bones.

Fig. 2.—Radiogram of the Hand of a Child, aged 3 years, severely affected by Rickets (Alban Köhler). The ossified shafts are clearer and more transparent than normal, and thicker. The epiphysial lines, especially of the radius and ulna, are broadened and not so clearly defined as in the normal specimen, and there is a greater abundance of calcified material, especially at the distal ends of the shafts of the metacarpal bones. Finally, the space occupied by the cancellous tissue of the shaft is greater, and the bones appear to be clearer and more atrophic toward the distal than toward the proximal extremity.

Fig. 3.—Radiogram of the Hand of a Rickety Child, aged 6 years. Compare this with Figs. 1 and 2. In this figure the thickening of the shafts of the bones is seen to have become permanent, although the epiphyses are sharply defined (Alban Köhler).

To face page 406.

violence, owing to the fact that, as time advances, the medullary tissue increases at the expense of the inner layers of bone.

Rickets disappear under appropriate treatment, and the process of ossification re-asserts itself in a more normal manner. Inorganic salts being deposited throughout the bony osteoid tissue, the bone becomes heavy and eburnated, and in some cases also of ivory hardness; but it is long before the hyperæmia passes off, as is evidenced by the hæmorrhage often seen in osteotomy.

Symptoms, Diagnosis, and Differential Diagnosis. — The rickety child, with large head, swollen abdomen, narrow chest, enlarged epiphyses, beaded ribs, and more or less curvature of the long bones, is readily recognised. As a rule it is pale and flabby. Many children, however, with severe rickets have a florid complexion; this is due to the arterioles of the face taking part in the general dilatation of small vessels throughout the body. Such children take a long time in recovering. If the child is wasted, it has a peculiarly wizened look. Dentition is delayed, and, when the teeth appear, they are craggy, pitted, deficient in enamel, soft, and decay readily. The musculature is feebly developed, and the child, if it has commenced to walk, is "taken off its feet."[1] Some bending of the long bones may be present at this stage.

FIG. 223.—General Rhachitic Deformities, showing distortions of the arms and legs, induced by posture (Royal Whitman).

A characteristic sign first noted and described by me is the occurrence of pads on the dorsal surfaces of the feet and hands.[2]

and only discoverable by X-rays. He also quotes a paper by John: *Über das Auftreten multipler Spontänfrakturen in früher Kindersalte*, Breslau, 1903. The inference is that skiagraphy should be used in every severe case.

[1] This is the osteo-paraplegia of Comby, *Le Rachitisme*, Paris, 1892.

[2] *Brit. Med. Jour.*, 15th October 1898.

In the course of examining a large number of rickety children, I was much struck by a peculiar appearance on the dorsum of the foot and occasionally of the hand, but more often on the foot. It is well known that in infants the dorsum of the foot is somewhat prominent and the soft tissues are fuller, yet the appearance and feel of this part are totally different in healthy and rickety children. In the latter, the soft tissues at this spot are decidedly thicker than in healthy children, and the swelling may be flattened or dome-like. Its colour is the same as is seen in the skin elsewhere in rickets, and may be compared to that which would be produced by the injection of white semi-transparent wax, slightly tinted to a yellow shade, beneath the skin.

As to the consistency of the swelling: if, in a healthy child, the skin of the dorsum of the foot be pinched between the fingers, it can be moved independently of the subcutaneous tissue; but, in many rickety children, skin and subcutaneous tissue are quite inseparable, and only a fold more or less thick and composed of both can be raised. It appears in many cases as if solid œdema were present in the skin and subcutaneous tissue.

The pad, however, is not due entirely to changes in the subcutaneous tissue, but in some cases originates in swelling and thickening in the neighbourhood of the epiphyses of the metatarsal bones; hence the pad is more frequently seen rather towards the anterior than the posterior part of the foot. When the bones are so affected, distinct beading may be felt about the epiphysial lines, and the perichondrium and periosteum of the shaft are thickened as well. However, to return for a moment to the consistency of the swelling. In early cases of rickets it is often semi-fluid, but in cases of a few months' duration it is semi-solid, and in those of more than a year's duration it is hard and resistant.

I have tabulated 100 cases of rickets, and, as it is somewhat difficult to fix the date of onset of the attack, it has been customary to ask the mother the following questions: When did the child's head begin to sweat persistently at night? When did he cry, as if he were tender all over? When did he appear to be weak in his back and go off his legs? When did the motions become evil-smelling and the abdomen swell? By carefully noting the answers to these questions—some, of course, being in the negative—it has been possible to fix the date of the onset of the attack with some degree of accuracy. Taking 100 tabulated cases

PLATE XIX.

1.

2.

3.

FIG. 1.—Radiogram of the Knee of a Normal Child, aged 6 years (Alban Köhler).

FIG. 2.—Radiogram of the Knee of a Child, aged 3 years, from whom the Photograph of the Hand (Plate XVIII., Fig. 3) was taken (Alban Köhler). Note the absence of clear definition of the epiphysial lines, and their breadth. The lower end of the shaft of the femur is much broadened.

FIG. 3.—Radiogram of the Knee of a Rickety Child, aged 6 years (Alban Köhler).

To face page 408.

of rickets, 86 had dorsal pads and 14 none. The 86 have been divided into 3 classes:—

(*a*) Those children in whom the pad was marked, but was semi-fluid, and no affection of the bones could be felt. Of the 86, 20 cases came under this category, the average age being 17 months, and the duration of the rhachitic attack 2 months. This statement bears out another observation, namely, that before the signs of rickets are seen or felt in the bones, the skin and subcutaneous tissues generally are affected, being puffy and of a tallow-candle appearance.

(*b*) Those in whom the pad was well marked, nearly dome-shaped, and solidly œdematous to the touch. Of the 86 cases, 49 presented this appearance; the average age was 27 months, and the average duration of the attack was $11\frac{3}{4}$ months.

(*c*) Those in whom the thickening was mainly bony, the swelling being of a firm, hard, resistant character, and beaded. Of the 86 cases, 17 came into this category, their average age being 4 years, and the duration of the disease 27 months.

Although only 100 cases have been tabulated, yet a very large number of similar cases have been examined and have appeared to me to bear out the preceding observations, and to indicate that, if cases be watched over a long period, the pad goes through three stages, namely, semi-fluid and confined to soft tissues; solid but soft, with some implication of the bones; and firm, resistant, and irregular; due entirely to the fact that the bone lesion is the last to disappear.

In conclusion, I would then advance the following points:—

1. In a large proportion of cases of rickets, the feet show definite dorsal pads, and in a smaller proportion of cases the same appearance is seen on the backs of the hands.

2. This pad is of varying consistency and origin.

3. If the disease is of recent duration—that is, 2 to 6 months—the thickening is subcutaneous and is semi-fluid.

4. If rickets has existed from 6 to 18 months, the pad is best marked, and is made up of thickened subcutaneous tissue and periosteum, and overgrown epiphyses.

5. At a period of 18 to 36 months after the onset of the disease, the subcutaneous pad disappears, concurrently with the general flabbiness and undue pallor of the skin, leaving the bony changes well-apparent to the touch.

In rickets, the disability of the limbs may be so extreme that care is essential to exclude paralysis.[1] Loss of power depends, apparently, partly on the feeble condition of the muscles, partly on the insecurity of the joints from ligamentous relaxation, and partly on the tenderness of the bones.

Bronchial catarrh, bronchitis, laryngissimus stridulus, and convulsions are met with. The spleen, and occasionally the liver, are enlarged, and the abdomen is distended and tympanitic. The recti are often separated, especially above the umbilicus, and the linea alba is widened. The bowels are rarely normal, either constipation or diarrhœa being present. Persistent sweating of the head, restlessness at night, and delayed dentition are highly suggestive of rickets.

The chief difficulty is to differentiate between congenital syphilis and rickets. Pseudo-paralysis, with epiphysial complications, is met with not only in rickets, but also in congenital syphilis and scurvy. As a rule, there is no difficulty in recognising the nature of the affection. Occasionally, however, some doubt may arise, and the presence of one does not necessarily exclude that of the others. A syphilitic child certainly may become rickety, or a rickety child become scorbutic. The chief points to be noted are the following:—

Syphilitic epiphysitis occurs in a child with other signs of syphilis, who is generally less than ten months old, and it is usually seen at about the third month. The onset is acute. There is a tender, œdematous, painful, and hot swelling, cylindrical in shape, and involving the juxta-epiphysial region of a long bone.[2] Softening of the disc of growing cartilage may become so marked that the epiphysis becomes loose, and can be moved on the shaft, with crepitus. The epiphysis may even lie in a cavity bathed in pus. Up to a certain point, which we are not able exactly to determine, improvement follows on antisyphilitic treatment. Separation of the epiphysis from the diaphysis is against the diagnosis of rickets; fracture of the shaft of the bone is in its favour. When a clear history of syphilis—however remote—in the parents is forthcoming, and the bones are affected before the sixth month, the assumption is in favour of hereditary syphilitic infection.

Pseudo-paralysis, arising from epiphysitis, is more often seen in syphilis than in rickets, and cranio-tabes occurs in both diseases, but is more common in rickets.

[1] Dr. Gee says a child who is not idiotic, or weakened by some recent disease, and who cannot walk at the age of 18 months, is either rickety or paralysed.

[2] The lesions are not so widely and generally distributed over the skeleton as in rickets.

In infantile scurvy the swellings are not limited to the region of the epiphysial cartilages, but encroach upon the shaft, so that whole segments of bone are surrounded by subperiosteal hæmorrhage. As a rule, however, the swelling begins near the epiphyses, and the presence of soft crepitus indicates that separation has taken place. The age of the child, usually eight to ten months, the dietetic history, and the presence of general signs of scurvy, suffice to make the case clear. Neither in syphilis nor in scurvy does green-stick fracture occur, yet it is seen in rickets.

Treatment.—Rickets can be cured as certainly by an appropriate diet as scurvy can be by an antiscorbutic diet, but spontaneous recovery is very doubtful, and when it occurs is due to an unpremeditated change in diet. Treatment must be begun early, and consists of giving plenty of fat, cream, milk, cod-liver oil, and butter, and of the ingestion of a sufficient amount of nitrogenous food, avoiding a preponderance of carbohydrates in the diet. In fact, treatment is a question of infantile dietetics, of sunlight and fresh air, and a change to the seaside or country. As the last is often impracticable in the case of the poorer classes, they must be taught that the open air in large towns, although dirty, is not poisonous.

Phosphorus is generally recommended. It is given, dissolved in cod-liver or olive oil in doses of $\frac{1}{200}$ of a grain, thrice daily after food for several months. However, Holt says: "I have been unable to satisfy myself, after several years' trial, that in the majority of cases phosphorus has had any decided influence upon the course of the disease. The best results from the administration of phosphorus are obtained in the early cases, where there are cranio-tabes and marked nerve symptoms."

Iron is useful when anæmia is present, and the most useful preparation is the compound syrup of the phosphate and tartrate.

On theoretical grounds, various calcium preparations have been given, especially the chlorides and lactates, which are assimilable.

Osseous Deformities in Rickets

CRANIUM AND FACE

The circumference of the head is often increased in severe cases by as much as perhaps one to two inches. The increase is due partly to hydrocephalus and partly to osseous thickening. Hydrocephalus is frequently met with in post-mortem examinations of rhachitic children. Ritterhain [1] met with hydrocephalus 38 times in 92 cases.

The conditions found in the skull vary with the severity, the stage of the disease, and the age of the patient when the malady began. In young infants, severely affected with rickets, large rounded bosses may be seen occupying the parietal and frontal eminences. The bosses may be so marked that a crucial sulcus can easily be recognised. The hypertrophy of the bone may be so considerable that in places the skull-cap measures half an inch in thickness.[2] Ossification is delayed at the margins of the flat bones in rickets, so that the sutures remain open for a long time, and the anterior fontanelle sometimes exists to the end of the third year.

The defective development of the bone, or absorption occurring in those parts exposed to pressure, results in more or less circumscribed [3] areas a quarter of an inch across, which are yielding to the touch, and on pressure give rise to the so-called "egg-shell crackling." This condition is known as cranio-tabes.[4] It is met with also in congenital syphilis.

Two facts support the view that cranio-tabes is due to pressure on softened bone. It is generally seen in the occipital region in infants, that is, where the pressure of the head on the pillow occurs; whilst in rickety monkeys the thinnest bone is met with in one or other parietal region, owing to the habit of those animals of resting in the sitting position, with one side of the head against a support.

A prominent and square forehead, with fulness of the lateral aspect of the frontal bones, flattening of the occipital region and vertex, sloping orbital roofs [5] with prominent eyes, delayed closure of the sutures and fontanelles, characterise the rickety skull. Those people who are dwarfed by rickets have a peculiar "water on the brain" appearance, as it is popularly called. The palate in

[1] Joachimsthal's *Handbuch*, Pt. i. p. 60.

[2] In hereditary syphilis the cranial thickenings are nodes rather than bosses, and are irregular, circumscribed, and osteoperiostitic in character. Sometimes they are distinctly tender, and occasionally break down.

[3] In a case which came under the author's observation at the Evelina Hospital for Children, the whole cranial vault was so softened that moderate pressure at any part produced an indentation.

[4] *Tabeo, tabēre*, to decay, be consumed.

[5] The oblique direction of the roofs of the orbits is partly due to pressure from within in cases of hydrocephalus; if this is absent the cause is not clear. The sloping roofs of the orbits partly account for the prominence of the eyes.

rhachitic children is high, and adenoids are often very troublesome. The defective rhachitic teeth we have already referred to.

In the face, the chief error of development is in the lower jaw. Makins[1] observes that "the defective development of the outer wall of the inferior maxilla interferes with the acquisition of the proper arch formed by the bone, the incisor teeth being arranged transversely; and from them the remaining teeth diverge obliquely backwards, the molars being somewhat inverted posteriorly, so that the teeth point inwards."

Rickety Torticollis

Phocas[2] reports three cases of rickety pseudo-torticollis in children aged 10, 15, and 18 months. The head was strongly inclined to the left, the chin elevated, and the face turned a little to the right. The sterno-mastoid was not contracted, and the head was easily replaced, but resumed its vicious attitude when support was withdrawn. Later on, the head was thrown more backwards, and posterior tilting was harder to prevent than the lateral. Pain was not severe, but the children were peevish and resisted examination. The lateral deformity lasted about three months, and the posterior also subsequently disappeared under appropriate general treatment and the use of a cervical collar. Phocas suggested that softening of the vertebræ and weakening of the muscles and ligaments were the causes of the trouble.

The Rickety Spine

The rickety infant sits "all of a heap," yet contentedly so, and in marked contrast to what is seen in Pott's disease. In the latter condition, if the infant is placed in the sitting posture, it soon evinces signs of distress, and, if left alone, quickly slides down into recumbency. Muscular spasm and rigidity also are present, but are not seen in rickets. Occasionally, especially if any taint of scurvy is superadded to rickets, muscular rigidity is found. It is very rarely that the differential diagnosis remains expectant.[3]

A ready means of making a diagnosis between kyphosis from

[1] Treves' *System of Surgery*, vol. i. p. 368.

[2] *Rev. d'orth.*, January 1894.

[3] It should be borne in mind, however, that rickets and Pott's disease may coincide, although it must be conceded that the event is rare.

Pott's disease and kyphosis from rickets is to turn the child on its face and raise the legs from the table. In Pott's disease, so soon as the attempt is made, distinct pain is elicited and rigidity of the spine occurs; whereas in rickets the spine can be hyper-extended without pain and with ease.

In rickets the child sits with his legs tucked up tailor-fashion. The spine, from the sacrum to the lower cervical region, presents one long, usually regular, convexity (rickety kyphosis). If the bend is more nearly abrupt, it is most marked in the lumbar or lumbo-dorsal region. The upper cervical vertebræ are lordotic, and the head is tilted laterally on the occipital condyles (pseudo-torticollis).

Rickety Scoliosis.—Slight evidences of scoliosis will frequently be found if carefully looked for, especially in infants who have been nursed with the pelvis resting obliquely. (See Vol. I. p. 466, and Vol. II. Fig. 224.)

FIG. 224.—From a photograph by P. Rédard, showing the effect of the position, in which a child is held by its nurse, in producing Scoliosis.

The spinal conditions are due in rickets partly to the intrinsic muscular feebleness and ligamentous laxity, and partly to osseous deformity. Specimens have been obtained in which the height of the vertebral bodies was distinctly lessened anteriorly in rickety kyphosis. That is, on sagittal section the bodies presented wedges, with the bases posteriorly.

The kyphotic element shows a remarkable and regular tendency to spontaneous cure. It is rare to see a persistent rhachitic kyphosis, as compensatory lordosis occurs.

Treatment of a Rickety Spine.—Infants and young children with marked rickety kyphosis may be treated on one of the following plans:—

Complete recumbency on the back, with suitable cushions, or, possibly, by means of a plaster of Paris bed, which is so moulded to the back as to produce the normal curves. As a variant to dorsal recumbency the child may lie prone for a time during the day. The best means of carrying it about is on a suitable tray (see Fig. 226).

When the rickety process is subsiding, and the child is able to stand upright with a certain amount of lordosis, a back-board (Fig. 227) is called for. Eppstein recommends the use of a swing, with the seat slanting downwards and forwards, so as to encourage

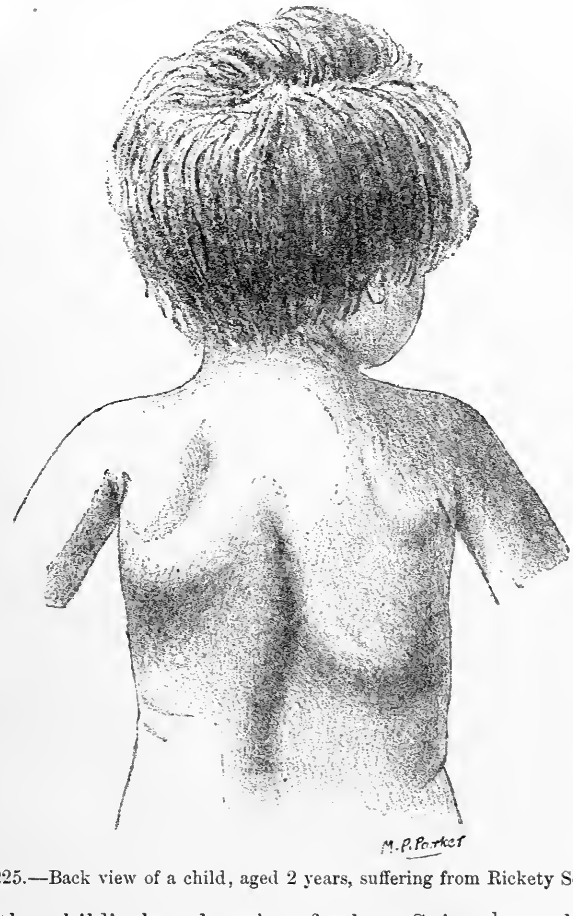

FIG. 225.—Back view of a child, aged 2 years, suffering from Rickety Scoliosis.

lordosis, the child's legs hanging freely. Spitzy[1] speaks well of this arrangement, and says that children take to it very kindly.

In rickety scoliosis the prognosis is not so good as in kyphosis, and, if the smallest amount of lateral deviation is noted, treatment must be prompt and thorough (see "Scoliosis," Vol. I. p. 493).

At a later stage, than the one to which these remarks apply, the spine often presents an exaggeration of the normal lordosis. This

[1] *Zeitschr. f. orth. Chir.* Bd. xiv. Hefte 3 and 4, p. 593.

is a feature of what is known as the "rhachitic attitude." The child stands with the feet widely apart, the thighs flexed, the knees bent, the back arched, and the shoulders thrown backward (Fig. 228). Considerable light is thrown upon the cause of this attitude in a paper by Arbuthnot Lane;[1] and in addition to the causes mentioned by that writer the lordosis is due to the prominent abdomen of rickety children.

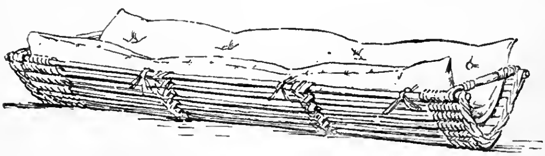

Fig. 226.—W. Adams' Spinal Tray, used in cases of Rickety Spine, when it is not advisable for the child to sit up.

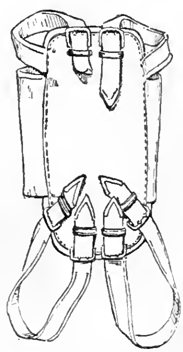

Fig. 227.—A Back-board, for use in the later stages of Rickety Kyphosis.

Fig. 228.—A Rickety child in a typical attitude.

Whitman suggests that the rickety attitude is simply an exaggeration of the normal kyphosis, balanced by an increased lordosis of a compensatory character. This is a simple explanation, and has much in its favour.

The Rickety Chest

Normally, at birth the thorax is more nearly circular than later. This fact is readily ascertained by making cyrtometer tracings of a child, aged one year, and of a child, aged five years (Fig. 229).[2] On

[1] *Guy's Hospital Reports*, vol. xxix. p. 32.
[2] Theodore Fisher, *Jour. of Children's Diseases*, Jan. 1906.

contrasting these tracings with one taken from a rickety child, aged two years, it will be seen that the circular form is to a certain extent retained (Fig. 230) or rather the transition to the oval or heart-shaped one is retarded (Holt). Further, in rickets, on account of the softness of the ribs, lateral grooving takes place. It is very marked in the axillary lines at a point farthest from the fixed extremities of the ribs.

It has been suggested by some[1] that the contact of the upper extremities with the sides of the chest may have a bearing on the condition described, but this is not the view usually accepted. Another vertical groove is often seen on the front of the chest, at

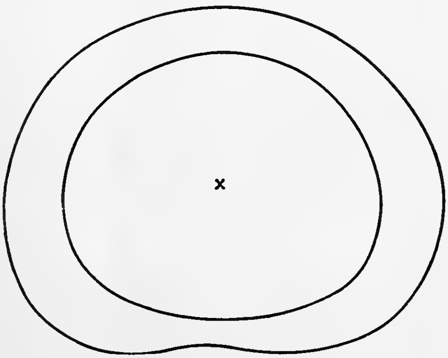

Fig. 229.—Outlines of the Chests of normal children (T. Fisher).

Fig. 230.—Outline of the Chest of a Rickety child.

the spot where the ribs are joined to the costal cartilages. This is where growth is very active, and the ribs yield at this point because they are softest.

A lateral, or rather an oblique groove, is also seen in the chest, corresponding to the highest level of the abdominal viscera. The lower ribs and cartilages are everted by the enlarged viscera, and it is noteworthy that the groove closely follows the attachments of the diaphragm to the ribs. It is quite probable that the pull of that muscle on the softened ribs is an important factor in the production of the groove. The groove in question is sometimes called Harrison's sulcus, and sometimes the rhachitic girdle. It is best marked at the sides of the chest.

When the chest is enlarged antero-posteriorly, and the sternum is prominent, the condition is sometimes spoken of as *pigeon breast*, or *pectus carinatum*. These terms, however, are better restricted

[1] *e.g.* Kirmisson, *Difformités acquises*, p. 348.

to the type of chest associated with early respiratory obstruction, prominence of the upper part of the sternum and collapse of the lower part. The beading of the ribs, or rhachitic rosary, is present in most cases. It is important to note that it may persist permanently, and is often seen in adults (Fig. 231).

The treatment of rickety chest consists of appropriate measures of a general character, and suitable respiratory exercises. It is often much aided by the removal of nasal or post-nasal obstructions.

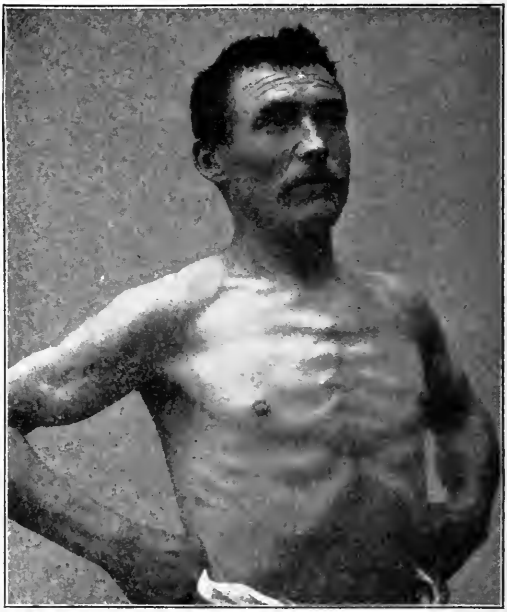

FIG. 231.—Rickety Rosary in the chest of an adult (Joachimsthal).

Fortunately, spontaneous cure is the rule, and the deformity is rarely seen in adult life.

It is said that exaggeration of the curves and subluxation of the inner end of the clavicle are seen in rickety children. The author has not met so far with any instances of this. Gibney,[1] however, alludes to several cases.

The abdomen in a rickety child is prominent, owing to enlargement of the viscera, flatulent distension of the intestines, and flabbiness of the muscular walls. The linea alba is often unduly widened, and in some cases there is a bulging of soft tissues in a vertical direction, beginning at the xyphoid cartilage, and extending

[1] *Internat. Clinics*, vol. iv., 1893, p. 239.

downwards to midway between the umbilicus and the pubes, or to just above the intersection of the pyramidales muscles.

Rickety Deformities of the Arms

They are comparatively rare,[1] and often disappear spontaneously. The rarity of their occurrence is due to the fact that once the crawling stage is past, the effect of the body-weight is absent.

The usual condition met with is curvature of the bones of the forearm, and the deformity is as often as not limited to one limb. It is as a rule convex backwards, with exaggeration of the normal physiological curve; however, lateral bending of the shaft of the humerus,[2] *cubitus varus* and *valgus*, may be seen.[3]

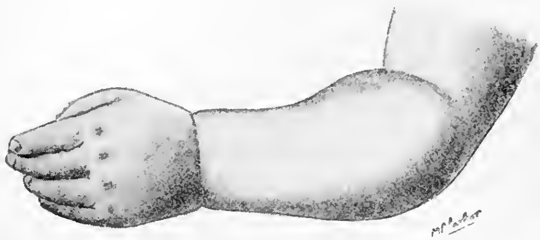

Fig. 232.—Rickety Curvature of the Radius.

In some cases, rickety curvature of the radius (Fig. 232) may cause a condition like that seen in Madelung's subluxation of the wrist. Recently attention has been called to a spindle-shaped enlargement of the phalanges of the fingers and toes, which is only observed in rickets, and, save in severe cases, not in children over one year of age. Radiography shows the condition to be due to periosteal changes.

When the author described the "dorsal pad" in rickets,[4] the spindle-shaped enlargement of the metacarpal and metatarsal bones was noted by him.

Treatment.—As a rule, little is required for curvatures of the diaphyses. They improve spontaneously, and it is quite possible that active treatment may prove worse than the disease. Osteotomy of the humerus is seldom or never needed, while operations on the bones of the forearm, in view of the difficulties of obtaining perfect union and position, are seldom advisable.

[1] Kirmisson examined 291 cases of rickets, showing curvature of the tibiæ, and met with deformities of the arms eight times.

[2] It is very rare, and was seen twice only in Kirmisson's 291 cases. The convexity is outwards, although the reverse condition is met with.

[3] Cf. Rieffel, "Étude sur le cubitus valgus et le cubitus varus," *Rev. d'orth.*, 1897.

[4] *B.M.J.*, Oct. 15, 1898.

Cubitus Valgus and Cubitus Varus

When the upper extremity hangs at the side of the trunk with the palm looking forward, the forearm is slightly abducted on the arm, that is, the long axis of the forearm is not continuous with that of the arm, but makes an angle with it, estimated by Mikulicz, to be on the average 164°; and by Potter to be 173° in males and 167° in females. This angle is known as the "carrying angle," and its existence should always be remembered in putting up fractures of the lower end of the humerus. When the angle is less obtuse than normal, cubitus valgus, and when greater than normal, or than 170°, cubitus varus is produced. Or to put it in a simpler form: With the upper extremity held in the position above mentioned, if the forearm is displaced too far to the radial side the deformity is cubitus valgus, and if too far to the ulnar side it is cubitus varus.

Observers are agreed that, normally the carrying angle is greater in females than in males, that is, cubitus valgus is more marked in women, and Hübscher holds that this difference in the sexes is not evident until the age of puberty. That is, the carrying angle is a development secondary to the increase in width of the pelvis.

Cubitus valgus and varus are due to traumatism, heredity, and rickets. Kirmisson refers to a case of Karewski, in which double cubitus varus in a rickety child was due to supporting her weight on the frame of an apparatus used for assistance in walking.

As in genu valgum and varum, it is found that in some cases the changes in cubitus valgus and varus are in the shaft of the bone, and in others at the epiphyses. The shaft of the humerus may be normal, with its lower epiphysis placed obliquely; or the shaft is curved, while the epiphysis is normal. According to Hübscher, the physiological cubitus valgus of women is due, not to changes about the joint, but to a bend in the lower third of the shaft of the humerus. Another point of similarity between cubitus valgus and genu valgum is found in the fact that the deformity disappears on flexion, and is most obvious on full extension. Sometimes the elbow can be hyper-extended, and this condition is called cubitus laxus, or, by Kirmisson, cubitus recurvatus.

Cubitus valgus rarely calls for treatment. The slight deformity is instinctively concealed by the patient's keeping the elbow somewhat flexed, and he experiences no great disability. Cubitus varus, which is generally of traumatic origin, and is particularly associated with transverse and oblique fractures of the lower part of the humerus, may seriously interfere with the "carrying angle," and may even lead to compensatory scoliosis.

The importance of the carrying angle is great (Fig. 233). The normal passive carrying position of the arm is with the humerus lying against the side, the bones of the forearm being abducted from the middle line, so that objects of moderate size can be carried in the hand without touching the thighs. In this position no muscular effort whatever is necessary so far as abduction at the shoulder-joint is concerned. Now, if the carrying angle be destroyed or lost, an effort must be made at the shoulder-joint to keep objects clear of the thighs, and it soon becomes very fatiguing.

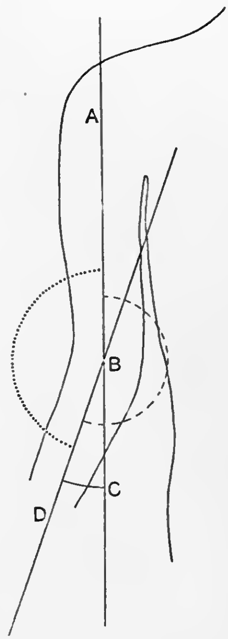

FIG. 233.—The Carrying Angle. AB, line of axis of the humerus; BD, line of axis of forearm; DBC, carrying angle (Vincent Moxey).

Treatment.—Treatment, *e.g.*, after a badly-set fracture, consists of supracondylar osteotomy of the humerus. Tilanus has divided the bone through an external incision, and Hoffmann and Davis through an internal incision. In the former case great care should be taken not to injure the musculo-spiral nerve, and in the latter case the ulnar nerve must be drawn aside. In fact, in the author's opinion, it is better to expose either nerve and retract them out of danger.

The deformity of cubitus varus after fracture cannot be dismissed without a word as to the position in which injuries in and about the elbow-joint should be treated. Inasmuch as cubitus varus or valgus are only evident in the fully extended position of the forearm, it may be claimed that injuries about the elbow-joint should be treated in this position, as we cannot be sure that in the ordinary right-angled position the carrying angle is preserved. This disadvantage, however, does not weigh against the possibility of ankylosis following the injury, and if it occurs with the forearm in the extended position the result is disastrous. Ankylosis, or limited movement in the flexed rather than the extended position, is infinitely more useful to the patient. Experience, has shown that if fractures in and about the elbow-joint are treated by fully flexing the forearm to as acute an angle as possible, and fully supinating it, the carrying angle is preserved.

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The Rickety Pelvis.—This presents the following characteristics: The conjugate diameter is decreased owing to the prominence of the sacro-vertebral angle; and in consequence of the inward thrust of the head of the femur at the acetabulum on either side, the lateral aspect of the pelvis is flattened, and the size of the pubic arch is diminished. The tubera ischiorum approximate unduly, while the ventera iliorum are expanded by the weight of the viscera upon them in their softened state.

The effects of these deformities of the pelvis on parturition are fully discussed in works on "Obstetric Medicine."

Rickety coxa vara is described in vol. i. p. 592; *coxa valga* in vol. i. p. 622; *knock-knee* in vol. i. p. 635; *genu varum* in vol. i. p. 657; *bow-legs* in vol. i. p. 658; and *flat-foot* in vol. i. p. 685.

The relationship of rickets to osteomalacia, chondrodystrophia fœtalis, osteogenesis imperfecta, and hereditary syphilis, are referred to in the descriptions of those subjects.

SECTION VIII

ARTHRITIS AND SPONDYLITIS DEFORMANS

CHAPTER I

ARTHRITIS DEFORMANS

Varieties—Still's Disease—Hypertrophic Arthritis—Atrophic Arthritis—Metabolic and Toxæmic Arthritis—Morbid Anatomy—Pathogeny—Course and Symptoms—Diagnosis—Prognosis—Treatment—General and Dietetic—Local Treatment, Balneological, Physical, Electrical—Surgical Treatment.

Synonyms—Rheumatic Gout; Rheumatoid Arthritis; Osteo-Arthritis; Rheumatoid Disease of the Joints.

THE name "arthritis deformans," suggested by Virchow, is the most convenient to group and describe a number of different conditions, and of diseases perhaps. Many synonyms are in use to some of which the adjective "rheumatoid" is affixed. Were it not that custom has decreed the use of this epithet, we would gladly avoid it, inasmuch as it leads to confusion, and there is no evidence that rheumatism has anything to do with the affections about to be described; nor has gout in all probability,[1] although by some this disease in the parents is said to be a factor in the production of arthritis deformans in the offspring.

It is well to summarise the affections at once. At the extremes of life we meet with two diseases:—

I. A peculiar joint affection of infancy and childhood, called Still's disease; and

II. A hypertrophic type of arthritis, usually designated osteo-arthritis, and met with in two forms:—

(*a*) The monarticular type of old age, exemplified by the osteo-arthritic hip-joint.

(*b*) The polyarticular type, met with generally in women past middle age, and exemplified by Heberden's nodosities.

These forms are possibly of metabolic origin. Then there is:

III. A type, atrophic so far as the bone is concerned, but

[1] M'Crudden, *Uric Acid*, Boston, 1905.

accompanied by hypertrophy of the synovial membranes and fringes, and seen in two forms:—

(*a*) An acute polyarticular variety, affecting children and young adults; and

(*b*) A chronic form, seen in middle life.

This type and these forms of the disease are by many writers described as "infective rheumatoid arthritis." Some, such as Goldthwait, speak of its being "infective," and others, of whom Macrae is one, are inclined to the belief that all forms are infective and the result of a toxin. We prefer, however, to limit the expression "infective" to such conditions as gonorrhœal, exanthematous, pneumococcic, staphylo- and streptococcic arthritis. It is striking, however, that these forms of joint affection are sometimes the antecedents of the atrophic type of arthritis. If, in using descriptive terms, we must be driven into the field of speculation, we prefer the term "toxæmic." The epithet "metabolic" commends itself less to us because it is vague, and there is even less agreement as to its correctness. For the sake of clearness, then, we avoid the word "infective."

P. W. Nathan [1] divides arthritis deformans primarily into two classes—the inflammatory (infective) and the degenerative (trophic); and according to the surgical location of the disease, into the synovial form (arthritis) and osseous form (osteo-arthritis). He claims that by "four simple and definite names we can indicate a distinct entity corresponding to definite pathological changes. Therefore there are: 1. Infective arthritis, involving the soft parts primarily. 2. Infective osteo-arthritis, involving the bones primarily. 3. Trophic (degenerative), involving the soft parts first. 4. Trophic osteo-arthritis, involving both bones and soft parts. Further, these names can be made still more definite if the ætiology is known—*e.g.* pneumococcic osteo-arthritis, a pneumococcic infection involving the osseous structure of the joints, having the general characters of infective osteo-arthritis; or neurotic osteo-arthritis, a trophic degenerative change involving the osseous joint structures as in tabes and syringomyelia." This classification, although simple and alluring, is not sufficiently exhaustive to embrace all the varieties, the forms, and divergences from types met with in the condition designated "Arthritis Deformans." The weak point is seen in the expression, "if the ætiology is known."

[1] *Amer. Jour. Med. Sci.*, June 1909, "The Nature, Diagnosis, and Treatment of Metabolic Arthritis."

We have made these quotations in order to demonstrate how confused the terminology of the disease is, and how difficult it is to present a satisfactory classification. We shall adhere to that which we have given on pp. 425-6.

STILL'S DISEASE

Dr. G. F. Still[1] described a peculiar form of arthritis occurring in infants and young children, and to the affection his name has

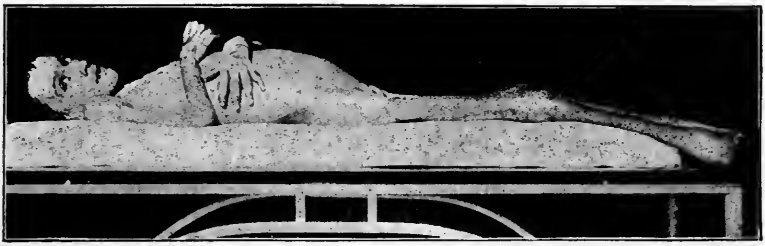

FIG. 234.—Still's form of Polyarthritis, showing the general atrophy, the enlarged joints, and the prominence of the abdomen, due to amyloid degeneration of the liver and spleen (Royal Whitman).

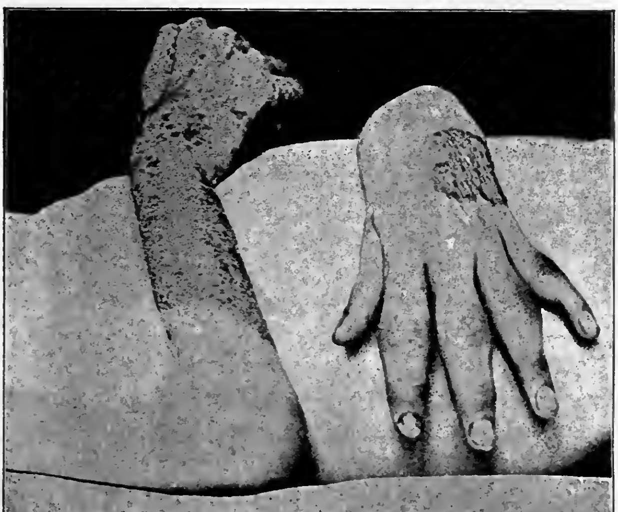

FIG. 235.—The Hands in the case, shown in the preceding figure (Royal Whitman).

been attached. On the subject of arthritis deformans in children,

[1] *Med. Chir. Trans.*, 1899, cf. also Spitzy; Goldthwait, *Boston Med. and Surg. Jour.*, 1904; R. Tunstall Taylor and S. H. M'Kim, *Trans. Amer. Orthop. Assoc.* xii. 303; Melsome, *Trans. Brit. Orthop. Soc.* vol. iv.

Still writes in Allbutt's *System of Medicine*, volume iii.; but the title "Still's disease" should be limited to a condition of arthritis deformans with special symptoms, and is not to be confused with the so-called rheumatoid arthritis.

The cause of Still's disease is unknown; inasmuch as the glands and spleen are enlarged, it is probably of an infective nature. Its onset is either acute or insidious, and it generally appears before the second dentition. In Still's cases it appeared between the fifteenth month and the eighth year. There is no bony irregularity

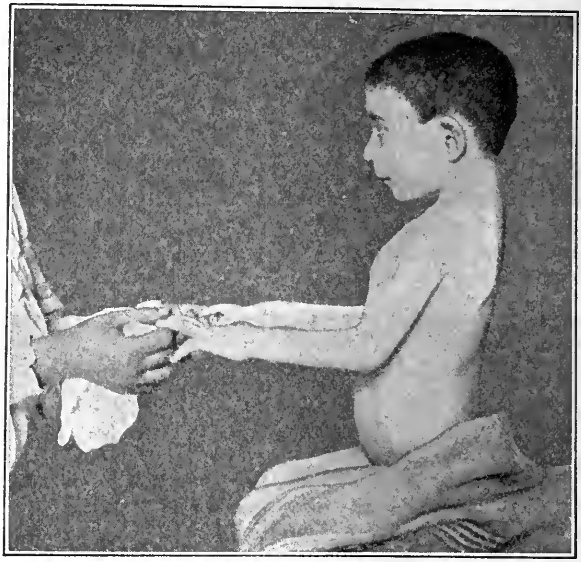

FIG. 236.—Atrophic Arthritis in a child affecting the Joints and the Spine, progressive in character, accompanied by Enlargement of the Lymphatic Glands. The attitude of the head is characteristic of suboccipital disease. The case is apparently one of the Still type (Royal Whitman).

and no grating, but creaking of the tendons in their sheaths and of the joint-cartilage, on movement, is present. The parts affected are tender and motion is limited. The disease is polyarticular. Neither suppuration nor bony ankylosis follows. Concurrently with the onset of the joint affection, the lymphatic glands, particularly those related to the joint, are implicated, become enlarged and tender, and may be so swollen as to be visible. When the joint affection subsides, the glands also diminish. The spleen exhibits changes in size concurrently with the lymphatic glands, and may become so large as to be felt one to one and a half inches below the ribs. Sweating is often profuse, and there is some intermittent fever of a slight type. Occasionally the eyes are prominent.

With the onset of the disease there is marked arrest of bodily development. Thus, a child aged twelve and a half years appeared to be only six or seven years of age, and had suffered for eight years.

The disease is not in itself fatal, although in the course of months or years it may leave the child a hopeless cripple. At a post-mortem examination at the Hospital for Sick Children fibrous

FIG. 237.—Arthritis Deformans in a child, aged 10 years (Bradford and Lovett).

adhesions in a joint were noted in one case, but there were no osteophytes and no fibrillation of cartilage.

This disease should be clearly distinguished from arthritis deformans of the polyarticular type, met with in children (Fig. 237), and of the same atrophic type as is seen in adults. In the latter cases there is an absence of splenic and glandular enlargement.

With regard to the treatment of Still's disease, it seems that the internal administration of arsenic, with plenty of good food, and a dry, warm, and equable climate are beneficial.

THE HYPERTROPHIC TYPE OF ARTHRITIS DEFORMANS (OSTEO-ARTHRITIS)

This is met with in two classes of case: those in which the monarticular type, such as an affection of the hip, predominates (Fig. 238); and those in which the polyarticular form is particularly in evidence, as in Heberden's nodosities (Fig. 240). These forms are undoubtedly degenerative, and certain factors are in evidence;[1] the most common is senility. It appears that this form may eventually supervene upon the atrophic type of arthritis deformans (rheumatoid

[1] B. L. Abrahams, *B.M.J.*, April 22, 1905, p. 873.

arthritis), continuing over a course of years; and, it is possible that repeated attacks of acute and chronic rheumatism, or even of gonorrhœa, may eventually lead to the osteo-arthritic changes in the joint or joints. Disorders of digestive metabolism are frequent; and probably the location of the disorder is determined in the monarticular form by trauma, and in the polyarticular variety by excessive use of the parts.

FIG. 238.—Arthritis Deformans. Monarticular Osteo-Arthritis of the hip, showing the destructive changes in the acetabulum and head of the femur (J. Riedinger).

Pathology of the Hypertrophic or Osteo-Arthritic Type.—"Bone destruction is combined here with bone formation, resulting in an irregular solid enlargement of the joint, and sometimes with distortion of the limb" (Whitman). It appears that the first signs of the disease are found in the cartilage, the cells of which undergo proliferation, burst their capsules, and the matrix undergoes fibrillation. At the spots where the greatest pressure occurs, the cartilage is worn away, whilst it is heaped up irregularly around the bone margins. The bone then becomes eburnated or sclerotic. As a result of the chronic inflammatory process in it, and owing to friction and pressure, it wears away in the course of time. The synovial membrane shares in the inflammatory process. It is at first injected and thickened, and later becomes hypertrophied. Its villi are enlarged, and in some of them cartilaginous nodules form. A distinct condition of villous overgrowth ensues, so that shaggy fringes project into the joint, and portions of them may become detached from time to time, giving rise to loose bodies or "joint-

FIG. 239.—Arthritis Deformans of the knee (Bradford and Lovett).

mice," and occasionally it is sometimes necessary to open the joint. Increase in the synovial fluid takes place, although as a rule the fluid is decreased in amount. The ligaments become relaxed, and sometimes are destroyed, whilst the tendons about the joint no longer play freely in their sheaths, and the muscles atrophy. Frequently, bony spurs form and project into the joint, causing mechanical obstruction, which is relieved by opening the articulation and chipping them away. At the hip a condition of subluxation is common, and the cavity of the acetabulum is greatly increased in size, and becomes shallow and irregular. The irregularity is due to the production of osteophytes, which originate partly from the cartilage at the periphery of the joint, and partly from ossification in the neighbouring tissues. A long-continued osteo-arthritis cripples a joint very effectually, and results in very considerable disability and deformity.

It is interesting to note that somewhat similar changes occur in ataxic patients, giving rise to Charcot's disease of joints; but there are essential differences between the two affections. In Charcot's disease the onset is very sudden, and the joint becomes disorganised in a few days. Fluid is almost invariably in great excess, whereas the contrary is usually the case in osteo-arthritis, and osteophytes are absent in the neuropathic form. These points are of interest as bearing upon the disputed question of the nerve origin of osteo-arthritis. Both the diseases are of degenerative origin, but there is no evidence to show that ordinary osteo-arthritis is neuropathic. Any joint, whether from strain, injury, or repeated inflammatory attacks, may become the subject of osteo-arthritis, and any cause which determines premature old age of a joint is sufficient to induce it. Poynton and Payne[1] produced a rapid monarthritis in a rabbit by intravenous inoculation of the culture of a diplococcus present in the synovial membrane of the knee-joint of a man aged sixty-seven years, several of whose joints showed the chronic destructive changes recognised as occurring in the osteo-arthritic type of arthritis deformans. In the rabbit an arthritis of the right knee resulted, and the joint showed destruction of cartilage and formation of new bone, peripherally placed, with some flattening and lipping of the articular ends, and definite wasting of the muscles in the neighbourhood.

FIG. 240.—Arthritis Deformans of long-standing (Heberden's Nodes). Marked enlargement of the distal phalangeal joints (Bradford and Lovett, by the courtesy of the Department of Surgical Pathology of the Harvard Medical School).

Symptoms.—The monarticular type usually commences in the hip or knee, or one of the larger joints, and subsequently other joints

[1] *Path. Soc. Trans.* vol. liii. p. 221.

PLATE XX.

Polyarticular Hypertrophic Arthritis Deformans (Osteo-arthritis). The hypertrophy of the extremities of the bones of the terminal phalanges (Heberden's nodes) is accompanied by erosion of the cartilage. The second interphalangeal joint of the second finger shows hypertrophy, combined with destruction and lateral displacement (Royal Whitman).

To face page 433.

become involved. Its onset is distinctly insidious, and it is often ascribed to muscular rheumatism. The pain is fairly constant, and is relieved at first by movement, but the joint, when at rest, is apt to become stiff. In a superficial joint such as the knee, distinct swelling of the part is noticeable, and there is irregularity of outline. The joint is not as a rule hot, nor is it markedly tender to the touch. Grating can be felt and creaking heard both by the patient and the medical attendant. Atrophy of the muscles occurs, and contractions with partial or complete ankylosis follows. The latter is of an extra- rather than of an intra-articular type, and due to the interlocking of osteophytes.

Heberden's Nodosities (Plate XX.) are examples of the polyarticular hypertrophic type of arthritis deformans. The disease is at first confined to the bases of the terminal phalanges of the fingers. I am not aware that it has been described in the toes. It consists of a gradual enlargement of the articular surfaces of the affected bones, and is often associated with flexion of the distal joint. Gradually it spreads to other phalanges until movement is lost, and the fingers are crooked and distorted. The pain is slight. It is a slowly progressive affection, and is frequently seen in women in late life. Afterwards, other and larger joints become affected.

Atrophic Arthritis (Toxæmic Arthritis) or Rheumatoid Arthritis

For the purposes of description the writer is reluctantly compelled to use the term "rheumatoid arthritis," because it is in common use, and to distinguish it from the other forms of arthritis deformans which have just been described. However, it must be definitely understood that, so far no clear connection of this disease with rheumatism has been established. The arthritis is an acute or chronic specific disease, liable to exacerbations. with definite and well-defined symptoms.

It is undoubtedly more common in women than in men, and in the former appears at the ages of fifteen to thirty years and at the climacteric. It is also seen in males in young adult or early middle life. No age is exempt, and distinct examples are met with in childhood. They are not to be confused with Still's disease, where enlargements of the spleen, liver, and glands are characteristic signs.

Atrophic arthritis is essentially a disease of debility, and follows persistent worry, over-work, loss of blood, habitual menorrhagia, intermittent leucorrhœa, uterine disorders, frequent child-bearing, and prolonged lactation. It is also associated with the menopause, and as we shall show with some forms of toxæmia. Many sufferers are chronic dyspeptics. They are pallid or sallow, flatulent and obstinately constipated. Joints which have been sharply and continuously used are liable to fall into degeneration or dystrophy; yet over-exertion is not a necessary, or even a usual antecedent of the disorder. The writer, however, has observed that when one leg is shorter than the other, the knee-joint on the shorter side often becomes affected with arthritic symptoms, which are relieved when the shortening is compensated. Joints which have been injured or are repeatedly strained are, so to speak, "selected" by the disease.

According to Hugh Lane,[1] the sufferers from this disease frequently have a mixed inheritance of gout and tubercle, and the family histories of some patients appear to support this view. This is important, in view of recent French writings on *Rhumatisme tuberculeux ankylosant.*[2]

Pathogeny.—This has been the subject of a great deal of discussion, and is not yet clear. Some observers believe in a bacterial origin,[3] but Painter was unable to find the organism of Bannatyne, Wohlman, and Blaxall. Other observers, such as Ross MacMahon, have taken refuge in the idea of a tropho-neurotic origin, and they have been doubtless influenced by the partial similarity of symptoms in these cases and those of Charcot's disease. Yet others look to toxæmia as a cause. Thus A. P. Luff[4] believes it to be an infection from one of the mucous membranes. Cave[5] thinks there are many channels of infection, chief among

[1] *Rheumatic Diseases*, 1892.

[2] P. W. Nathan, *Amer. Journ. Med. Sci.*, June 1909, says: "Typical metabolic osteo-arthritis may occur in the course of pulmonary tuberculosis, and in three forms: 1. Monarticular forms of trophic osteo-arthritis (senile type); 2. Hyperplastic periostitis or ostitis (osteo-arthropathie hypertrophiante pneumonique, Marie), so-called club-fingers; 3. Metabolic osteo-arthritis. That so many diverse conditions should occur under these symptoms is not surprising, when it is considered that the tubercle bacilli secrete no toxin, but cause toxæmic or general disturbance, because of the disintegration of the tubercle bacilli themselves."

[3] Schüller, *Berl. klin. Wochenschr.*, 1893, 865; Blaxall, *Lancet*, 1896, vol. i. 1120; Bannatyne, Wohlman, and Blaxall, *Lancet*, April 25, 1896; Pribram, *Chr. Gelenkrheum. und Osteoarthritis Deformans*, Wien, 1902, p. 95; Teissier, "Du Rhum. goutteux," *Lyon Méd.*, 1897, p. 169.

[4] Medical Society of London, November 27, 1905.

[5] *Lancet*, August 3, 1901.

them being the alveolar sockets of the teeth. In this connection, and having been under a similar impression, I have examined the mouths of patients coming under my notice, and have almost invariably found some carious teeth. Mr. J. Lewin Payne, Assistant Dental Surgeon to Guy's Hospital, has examined the joints of patients coming to him with carious teeth, and he frequently finds evidences of arthritis deformans. It is certain that in all cases it is advisable to look for some source of septic absorption, such as the teeth, uterus, or rectum. Thus Cave noted a rectal ulcer in one case. A few observers[1] look upon congestion of the spinal cord as the immediate forerunner of the affection. This may be the immediate result of toxæmia.

It is certain that most of the cases show evidence of malnutrition and frequently of defective metabolism. It is striking to note how often constipation, with evil-smelling stools, is present. W. H. Bain[2] suggests that there is a diminution in the excretion of uric acid and phosphates in the urine.

The weight of evidence is in favour of the disease being an auto-toxæmia. The most helpful communication on this point has been made by C. R. Andrews and Michael Hoke,[3] entitled *A Preliminary Report on the Relation of Albuminous Putrefaction of the Intestines to Arthritis Deformans (Rheumatoid Arthritis, Osteo-arthritis) and its Influence upon Treatment*; and we quote *in extenso.* The writers remark that "the digestive tube of man may be likened to an incubator containing culture media, in which bacteria may flourish, and the various fermentative and putrefactive changes take place. The temperature is maintained constantly at about 37° C., and a large portion of proteid material is changed into peptone. The facility with which bacteria flourish upon this substance is well known. There is always moisture and the absence of light—in fact, every condition which is conducive to bacterial growth. The human digestive tract always contains micro-organisms in large numbers. Amongst them are *Bacillus coli, B. butyricus, B. aerophilus, B. aerogenes capsulatus, B. lactis aerogenes, B. putrificus,* and *B. proteus vulgaris.*"

"Dr. Herter mentions three types of chronic excessive intestinal putrefaction:—

"(1) *The indolic type,* occurring in the small as well as in the

[1] P. W. Latham, *Lancet,* April 6, 1901.

[2] *Lancet,* March 10, 1900.

[3] *American Journal of Orthopedic Surgery,* vol. v. p. 61.

large intestine. Quantities of indol are produced, and the stool is usually alkaline. *B. coli* probably plays the most important *rôle* in this type.

"(2) *The saccharo-butyric type*, occurring in the lower ileum and large intestine, and produced for the most part by the anærobic butyric acid types of bacteria. In this type the indol is slightly if at all in excess, and the stool may be acid.

"(3) *The combined indolic and saccharo-butyric types.*—The number of bacteria is influenced in several ways, especially by increase and decrease of the amount of albuminous food taken; and, since it is albuminous foods which putrefy, the indications are either to decrease this class of food, or to introduce it in such a form as to preclude putrefaction. The fact that putrefying material is toxic is unquestionable, the symptoms depending on the quantity of material supplied to produce putrefaction."

Andrews and Hoke quote five cases of rheumatoid arthritis, where albuminous putrefaction in the intestine existed, and a remarkable improvement followed the correction of this process, and they infer that a distinct relationship exists.

We may now advance our views, but we do so with some diffidence. Still, it is essential, in dealing with so disabling a disorder, to have some rational basis to work upon. The records of cases frequently show either that some septic disorder such as gonorrhœa or influenza has occurred shortly before the first symptoms, or that the patient's resistance has been lowered by hæmorrhage, overstrain, overwork, and constant worry. In other patients we find lesions present which have been shown to be of undoubted septic origin, such as carious teeth, enlarged tonsils, chronic nasal and post-nasal catarrh, vaginitis, leucorrhœa, endometritis, or ulceration of the rectum. It will be objected that there are many people who are afflicted with arthritis deformans and yet have no such lesions. Chemical investigations and analysis of the urine and fæces from many of our patients show that intestinal putrefaction is excessive, that chronic pancreatitis is present, and that duodenal digestion is not carried out normally. From our own practice we can adduce many examples of this type of case. We have also noticed that some of these patients have either had distinct attacks of appendicitis, or from time to time have suffered from pain in the right iliac fossa, with flatulence and constipation. Others have had membranous colitis. Therefore we have inferred that in these instances the stomach and intestine have lost their immunity to invasion by the bacillus coli; and we have acted on this hypothesis and vaccinated with dead B. coli, with excellent results. Doubtless, too, the effect of guaiacol and of salol is explicable by the disinfection which they produce of the intestinal canal. Incidentally, it may be remarked that in some of our cases, streptococci were found in the fæces, and the patients have been vaccinated. In one case the striking symptom of the arthritis was a periodical swelling of the knees and ankles occurring every tenth day, lasting two or three days and then passing away.

We infer then that intestinal toxæmia is a potent cause, and that the chief agent is the perverted and migratory bacillus coli.

The next question which arises, Does the toxæmia affect the joints through the spinal cord, and if so, how? Or does it act upon the joints directly through the blood?

Taking the hypothesis that the spinal cord is involved, we have the following facts. That the nerve-lesions are produced by the toxins of the exanthemata and other infectious diseases, particularly, as is well known, of influenza. The joint symptoms of arthritis deformans in some respects bear a relationship to those seen in tabes dorsalis and syringomyelia. Although the process of destruction is not so acute, yet we see in both a progressive disorganisation of the joints. The symmetry of the affection, hand and hand, knee-joint and knee-joint, is alone explicable by the loss of some central controlling factor, and by a selective action. Arthritic patients have increased reflexes, and, late in the disease fibrillar contraction of the muscles occurs, even when they are at rest. The alteration in the reflexes may be due to lowering of the general health, but this does not explain the fibrillar muscular movements. Spender pointed out years ago that most of the sufferers have tachycardia, and vaso-motor disturbances are very common. It is also a fact worth noting, that those who suffer from psoriasis are frequently attacked with arthritis deformans, and the conditions may be in some way related. According to French observers skin lesions are far from uncommon in polyarthritis, and glossy skin with brittle nails are present in some cases, while scleroderma and angio-neurotic œdema have been seen occasionally. Pigmentation is a common occurrence.

Whilst these observations are not free from criticism, yet they, in the writer's opinion, go a long way towards supporting the view that in arthritis deformans some alterations in the circulatory conditions and trophic influence of the spinal cord are present. It may be congestion or it may be anæmia, but there are no records to show that any structural change has been found.

The argument may be advanced, Why should an alteration in the trophic influence of the cord produce lesions in the bones and joints alone? The answer is simple. The lesions are found in the soft tissues near the joints as well, and muscular wasting is too excessive to be explained by disuse.

We now ask the question, Is the toxæmic condition of the blood primarily responsible for the effects in the joints, *i.e.* does it act directly on them? If so, how are we to explain the symmetrical nature of the affection so far as the joints are concerned, why again hip and hip, knee and knee, hand and hand? Here we must leave this interesting discussion. We think, however, as Nathan does, that to describe some cases of arthritis deformans as metabolic, and others as tropho-neurotic, begs the question.

FIG. 241.—Arthritis Deformans (Atrophic Arthritis, Rheumatoid Arthritis) of the hand (Bradford and Lovett). Note the fusiform shape of the articular swellings.

Morbid Anatomy.—The affection is a polyarticular one, and the changes begin in the synovial membrane, which is injected and thickened. The folds become enlarged, and villi form. In them, sometimes cartilage, and even bone, forms later. In other cases the synovial villi undergo fatty degeneration, to which the term "lipoma arborescens" has been applied.[1] The capsule becomes relaxed, and the joint is thereby weakened. The cartilage is soon attacked and shows atrophic changes, and becomes first vascularised and then thinned. It may be covered with granulations or fibrous tissue. The sites of greatest thinning of the cartilage are the points of pressure, and at these points it splits, ulcerates, and disappears altogether. Where the cartilage is not eroded, osteoid cells apparently invade it and develop into bone. The changes in the bone are of an atrophic nature. At first it appears to be more

[1] Painter and Erving, *Amer. Jour. of Orthop. Surg.* vol. i. No. 2, p. 109.

translucent to X-ray illumination, and the trabeculæ stand out more clearly than normal, while the compact tissue is thinned. Later on, absorption of bony surfaces occurs. In the periarticular tissues, fibrous thickening takes place, especially at the attachment of the capsule to the ligaments and the insertions of muscles, and in such thickenings bone may ultimately form, so that a periarticular hyperostosis results. The muscles around the joint undergo rapid atrophy and sometimes fibrous degeneration, often becoming con-

FIG. 242.—Arthritis Deformans following Gonorrhœa. Considerable boggy swelling of and effusion into the joints. Ulnar deviation at the proximal phalangeal joints (Bradford and Lovett, by the courtesy of the Department of Surgical Pathology of the Harvard Medical School).

tracted, particularly on the flexor aspect. The general effect is one of hypertrophy of soft tissues, especially of the articular and periarticular, and atrophy of bone and cartilage, with occasional extra-articular development of new bone. The increase in the synovial fluid is variable. Usually it is clear, but in some cases turbid.

Erving[1] states that no signs of hæmic degeneration are found, nevertheless, noting the pallor of many of these patients, it is difficult to explain the discrepancy between clinical observations and microscopical findings.

[1] *Amer. Jour. of Orthop. Surg.*, November 1903.

In the description of the pathology and the morbid anatomy of osteo-arthritis and rheumatoid arthritis, the two conditions are often merged one into the other, and Painter[1] quotes the following results from the specimens examined by him:—

"(*a*) The femur of a man aged twenty-six, the subject of rheumatoid arthritis for five or six years; the hip was excised for vicious ankylosis, and the cortex of the bone was found to be thinned, and could be crushed with the fingers, while the bone itself was spongy and loaded with fat.

"(*b*) Specimen from the excised elbow of a woman aged twenty-six, showed that very little of the cartilage was left, and what remained was in the form of greyish islands. The trabeculæ were much attenuated.

"(*c*) A girl aged seven years, whose knee-joints were opened. They were found full of fluid, in which were many coagula. The synovial membrane was studded with cartilaginous islands, varying in size from a pea to a thumb-nail. There were erosions and fibrillation of the cartilages. Histologically, it was observed that the blood-vessels were in excess in the hypertrophied villi, and were affected by endarteritis. There was fibrous and myxomatous tissue in abundance, and part of it had been transformed into bone and cartilage.

"(*d*) In another case, marked proliferation of the synovial membrane, the tips of the villi being packed with cells, while the bases were fatty."

It is noteworthy that in atrophic arthritis the intra-articular adhesions come on very late, and they are dependent upon extensive degenerative erosion of the cartilages, so that cancellated bone (not eburnated) comes in contact with cancellated bone, and true bony adhesion then occurs. In osteo-arthritis there is less atrophy, and no synovial swelling. The enlargement of the joint is due to hypertrophy of the bone ends, and to the presence of asymmetrical bony outgrowths. Eburnation of the bone-ends is present. For fuller information on the morbid anatomy of atrophic arthritis we refer the reader to the bulletins issued by Dr. Strangeways of the Cambridge Committee for the Study of Special Diseases.

Course of the Disease.—The main points have been mentioned above, and it is not necessary to repeat them, but the question of the existence of acute rheumatoid arthritis merits notice. In this connection it must not be forgotten that comparatively mild attacks

[1] *Trans. of Amer. Orthop. Assoc.* vol. xiv., 1901.

are liable to acute exacerbations. Bannatyne claims[1] that there are two stages of the disease, and his view is upheld by Ziegler, although it is strongly controverted by Painter, whilst Bertram Abrahams[2] stated "that the line of cleavage of cases of arthritis deformans does not divide them into acute and chronic. It is much more probable that the clinical description, largely based on reaction to treatment, put forward by Dr. A. E. Garrod, is on the track of the truth." Those who have watched cases have observed that when a large joint is affected, in a few weeks there is often a sudden invasion of other joints. We have seen, for example, one knee affected, then, in three weeks' time, the second knee acutely painful, and in seven weeks from the first visit of the patient, both elbows affected. As to the order of frequency, we think that it is most often seen in the knees, then the wrist and hand, shoulder, ankle, jaw, hip.

FIG. 243.—Hand in Arthritis Deformans, showing a fusiform enlargement of the middle finger (Bradford and Lovett, by the courtesy of the Department of Surgical Pathology of the Harvard Medical School).

Symptoms.—According to Hugh Lane[3] the preliminary signs are the following:—General weakness and lassitude, anæmia, emaciation, anorexia, arthralgia, and functional neurotic conditions. The onset is often sudden, although it may be gradual. The anæmia is a constant and early sign; it does not pass into a chlorotic, but rather to a yellowish brown tint, which is irregular in distribution, and may deepen so as to form actual patches of pigmentation. The pulse is often increased, and may be over 100 per min. Periodical sweatings take place, at first general, and then local, whilst many of the patients suffer from migraine. The temperature chart shows intermittent pyrexia. In fact, in a doubtful case we are bidden by the late Dr. Kent Spender[4] to count the pulse, look

[1] *Loc. sup. cit.*
[2] *B.M.J.*, 9th December 1905.
[3] *Rheumatic Diseases*, 1892.
[4] Allbutt's *System of Medicine*, vol. iii.

for spots, stains, and marasmus, note the cold and sweating hands, inquire for neuralgic twinges in the limbs; if these signs are present, together with joint-symptoms, then the diagnosis of atrophic arthritis is established.

Quiescent periods occur from time to time. The affection is

Fig. 244.—Rheumatoid (atrophic) Arthritis. Slight superficial erosions of the bones are to be seen at several of the joints. Contrast with osteo-arthritis (Royal Whitman).

primarily one of the fibrous coverings and the membranes of the joints. Thus spindle-shaped enlargement of the finger-joints is common and typical (Figs. 241, 242); an X-ray photograph shows a normal contour, but no irregular bone formation, as in Heberden's nodes or typical osteo-arthritis. Similarly, in an early stage the outlines of the knee-joints are puffy, and swelling is noticeable in the

PLATE XXI.

Atrophic Arthritis Deformans of the Foot in a man, aged 20 years. Fusiform swelling of the first interphalangeal joints of the second, third, and fourth toes is well marked. There is also distinct evidence of atrophic changes of the bones in these situations, contrasting with the normal shadows elsewhere (Alban Köhler).

To face page 442.

PLATE XXII.

Atrophic Arthritis Deformans of the Knee in a man, aged 51 years. The two dark spots indicate osteophytes in the tibio-fibular joint. The outer condyle of the femur is separated by a space, abnormally wide, from the external tuberosity of the tibia. The articular ends of the bones are broader and generally thickened. Finally, the bones, especially the tibia, show atrophic changes (Alban Köhler).

To face page 443.

patellar pouches of the synovial membrane. There is decided and early atrophy of the muscles in the hand, particularly of the thumb and interossei muscles, and, in the lower limb, of the extensor muscles of the thigh. The affected joint is often a little hot to the touch. The arthralgia is not affected by a change of weather, and some patients feel better on a wet day. The pain is often more noticeable in bed, especially towards the small hours of the morning. It attacks the whole limb and simulates neuralgia, and is often followed by severe perspirations. In the early stages, and when the disease is subacute, I have noted in the knee-joints a sensation of fine or silky crepitation, like that felt in teno-synovitis, and as the joint becomes less painful and tender this fine crepitation changes into a coarse crackling. These facts should be borne in mind in treatment. With regard to the swelling, it varies both in extent and position. In mild cases, and at an early stage, little or no enlargement is present, but there occurs later, especially in the fingers, a typical fusiform swelling, composed of thickened periarticular tissues, capsule, and ligaments.

Stiffness.—At first there is little loss of flexibility in the joints; subsequently the overgrown villi obstruct the free movement of the part, and the limitation is aggravated by muscular spasm and contraction. In the hands the ultimate deformity assumes one of three types: flexion at the metacarpo-phalangeal joints, with hyper-extension of the first interphalangeal, and flexion at the second interphalangeal articulations; a complete reversal of this; or deflection of the fingers to the ulnar side of the hand. As a final result, the joints are left distorted, thickened, more or less useless, from partial or fibrous ankylosis, or complete fixation in a vicious position. The skin is often glossy and pink, and is the site of vasomotor disturbances; whilst the subcutaneous tissues and the fasciæ are seen to undergo nodular thickening, as, for example, in the plantar fascia or in the palmar fascia; and in the latter case it may constitute one form of Dupuytren's contraction.

It seems from the symptoms we have described that poly-articular atrophic arthritis constitutes a distinct entity. It is true that certain writers beg the question, and say that the atrophic form of arthritis deformans or rheumatoid arthritis eventually merges into the hypertrophic form, or osteo-arthritis; but enough has been said to show that they are essentially distinct conditions.

Prognosis.—When the disease attacks the young, and in the polyarticular form, the outlook is often disastrous, for despite all treatment the patient may in a few months or a year or two become a helpless cripple, with distorted and ankylosed limbs. When the disease comes on in middle life, particularly at the climacteric, it is of an intermittent character. As the patient's health improves, the symptoms abate; but, they are evoked by fatigue, worry, overwork, or by persistent hæmorrhage. In most instances the affection is fortunately of a mild character, with increase from time to time, but it is capable of relief under skilful treatment. In fact the disease, though present for years, may not cause serious interference with comfort or usefulness.

Diagnosis.—We have detailed the symptoms of the various forms of arthritis deformans sufficiently for diagnostic purposes, and we have endeavoured to make clear the distinctive points of each. Now we may make a few remarks bearing on differential diagnosis.

In young subjects confusion often arises between this disease and tuberculosis. If the case is doubtful, the opsonic index should be taken, inoculation experiments performed, and the X-rays used. In certain cases, where doubt remains, and the intensity of the symptoms warrants it, an incision into the joint should be made. As a rule, both in children and in adults, a chronic non-suppurative progressive articular affection affecting several joints is usually non-tuberculous. Some French authors[1] describe a form of "acute tuberculous rheumatism"; it is difficult to understand precisely what they mean by it, although there is no doubt that, clinically, difficulty often exists in diagnosing tuberculous from rheumatoid conditions; and Nathan has pointed out that a metabolic osteo-arthritis may exist in the course of pulmonary phthisis.

Much confusion still exists, but fortunately less than formerly, between rheumatic arthritis and rheumatoid arthritis. As to the former, it may be said that it is essentially chronic, there is a definite history of acute or subacute rheumatism, the capsule of the joint is not so thickened as in rheumatoid arthritis, and there is no effusion. The joints do not present the typical spindle-shape of rheumatoid arthritis, but the articular ends of the bones are exaggerated, and the swelling ends abruptly above and below each joint. The young are seldom affected, and the poor suffer more than the rich. The disease is worse in wet and cold weather. The

[1] P. Gauthier, *Rev. d'orth.*, July 1, 1905; Leriche, *ibid.*, May 1, 1905; Patel and Leriche, *ibid.*, May 1, 1906; also Poncet and Leriche, *Acad. de méd.*, 30 Mai 1905; Moutet, *Th. de Lyon*, 1903-04; Pic de Bombes et Villiers, *Lyon méd.*, Oct. 4, 1903; Thévenot, *Méd. mod.*, Mai 4 and Août 19, 1903.

neurotic elements are absent, and nervous symptoms are wanting; and it is not often that symmetrical joints are attacked. It is stated by Hugh Lane that the temporo-maxillary joint is never affected, as in arthritis deformans. In the rheumatic form the heart is often diseased. Muscular atrophy is a late sign, and then only arises from disuse, and is not seen, as in rheumatoid arthritis, in the early stages. The finger-joints are often extremely flexed, but there is little or no pain, and sometimes swelling is entirely absent.

Having decided that the case with which we are dealing is one of arthritis deformans, it remains for us to ascertain *the cause.* A systematic investigation should be carried out, and the writer adopts the following plan:—

The history of the patient is taken, and any account of infectious disorders carefully noted, or any cause likely to deteriorate the patient's health. The position of the affected joints is observed, and their condition and that of the surrounding parts. Symptoms which have been detailed on pp. 441-2 are looked for and their presence or otherwise recorded. The author now endeavours, particularly in cases of atrophic arthritis, to find out if any source of septic infection exists. The mouth, nose, pharynx, naso-pharynx, and maxillary antrum are examined, and especial care is given to the teeth and tonsils. If a chronic nasal or aural discharge is found, it is examined bacteriologically and reported upon. Inquiry is then made for any other discharges. In women, the presence of leucorrhœa is noted, and the patient is referred to a gynæcologist for examination and to a bacteriologist for report. The rectum and anus are also examined for ulcer, fissure, fistula, or piles. If the results prove negative, then the patient is directed to send a specimen of urine and fæces to a skilled pathological chemist for a qualitative and quantitative analysis, especially on the question of excessive putrefaction in the intestines; and his opinion as to the cause is sought. He is also asked to report on the presence of free blood and the identity of the bacteria in the fæces. In a large proportion of cases of the atrophic type of arthritis deformans some abnormality will be detected in the digestive process. It is seldom that failure is encountered in ascertaining the cause of toxæmia, when such a systematic examination is made, and in the treatment of arthritis deformans half of the difficulty is now over, for unless the joint symptoms are very far advanced, great improvement can be effected, and in slighter and earlier cases permanent relief can be assured.

If we are dealing with the monarticular form, a similar investigation is made, often with gratifying results. It is unreasonable and unscientific to treat only the joints, which are merely local expressions of a general disorder, or to drug the patient blindly, unless the actual cause of the disease be ascertained.

Treatment of Hypertrophic Arthritis.—In the *hypertrophic* or *osteo-arthritic* form, particularly of the senile variety, the general health of the patient is to be maintained, and he should live on a dry soil. In the winter a change to a warmer climate is recommended,

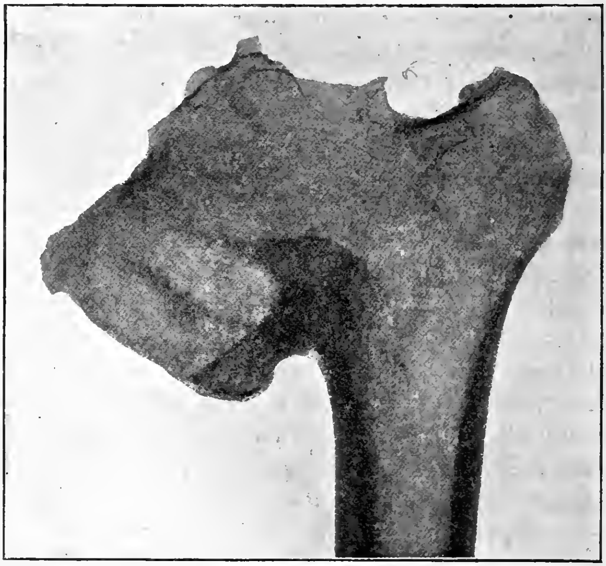

Fig. 245.—Hypertrophic Arthritis Deformans (Osteo-Arthritis) and Coxa Vara (F. Hofmeister, after V. Brunn).

and at other times visits to watering-places, such as Strathpeffer, Buxton, Bath, Droitwich, Woodhall Spa, or Aix-les-Bains, with appropriate baths, douchings, or shampooings, often cause some alleviation. Care should be taken that the diet is plentiful and nutritious, but any excess of nitrogenous extractives and carbohydrates is to be avoided. Locally the joint should not be kept at rest, and the patient must use it within the limits of fatigue. We shall allude to massage and electricity in speaking of the atrophic form; they are also very useful in the hypertrophic type. It is desirable in every case of hypertrophic arthritis to ascertain if any defects of metabolism or any source of toxæmia is present, because at this time of life, in which more particularly the senile form occurs, derangements of the liver and pancreas, gall-stones, and cholecystitis are common.

The surgical treatment will be discussed in conjunction with that of atrophic arthritis.

Treatment of Atrophic Arthritis (*Rheumatoid Arthritis*).—It is difficult, on account of the doubt which appears to exist in the minds of many writers as to the identity of the disease, to ascertain which particular measures are valuable and which are useless. So that we shall largely confine ourselves to those which, in our experience, we have found useful in arthritis deformans.

Fig. 246.—Arthritis Deformans (Atrophic) of the left knee with secondary genu varum (A. Schanz).

Preventive Treatment.—In a patient threatened with this disorder, and before the joints are manifestly affected and swollen, the treatment is very much on the same lines as in early phthisis. The patient should have plenty of rest, go to bed early, and as a rule be in bed ten hours of the twenty-four. All fatigue, worry, and overstrain are minimised. Many of these patients are much benefited by a sojourn in the High Alps, and they tell us that, when there, all the aches, pains, and stiffness disappear, probably owing to their resistance to the toxæmia being increased. If anæmia is present, iron, arsenic, a generous diet, avoiding excess of meat and carbohydrates, are required. For some patients, where the air of the High Alps induces restlessness and insomnia, a sea voyage is beneficial. Any depletion of the patient, whether general or local, is to be avoided, yet careful attention is to be given to the bowels; and a saline purgative, either Contrexéville, Plombières, or Carlsbad water three times a week, before breakfast, is essential. In some instances, despite this course of treatment, the premonitory symptoms prove refractory. Then, thorough examination for all possible causes of toxæmia must be made. We have indicated the lines on which it is carried out, when speaking of diagnosis.

General Treatment.—The measures described under preventive treatment are persevered with, and we are guided by the results of our investigations for the cause of the toxæmia. If it is the teeth, old roots are extracted and carious teeth stopped, and an antiseptic mouth-wash is used at least three times a day. Abnormal conditions of the tonsils, nose, and naso-pharynx, maxillary and mastoid antra, are treated, and in any event the opsonic reaction of the blood to septic organisms present in the mouth or in nasal and aural discharge is ascertained. Frequently it is advisable to inject the appropriate vaccine. Uterine and rectal discharges are treated on similar lines, and here we wish to remark upon the prevalence of *B. coli* in uterine discharges. It is noteworthy how soon many vaginal discharges clear up after vaccination with the *B. coli.* In many patients no overt cause of toxæmia is present, and it remains to examine the urine and fæces. When excessive putrefactive changes are going on in the intestine we advise the following treatment, carried out on the lines advocated by Andrews and Hoke, which is largely a matter of—

Appropriate Diet.—Many sufferers have been advised to take plenty of meat, and avoid an excess of carbohydrates. With the latter part of the advice we agree, and with the former we disagree, for proteid food in the form of meat means albuminous putrefaction, of a virulent type, as shown by an alkaline instead of an acid reaction, and the foul, penetrating odour of the fæces. The writers, recently referred to, point out that "when stomach-indigestion is present, particles of fibrous tissue, and of the sarcolemma surrounding the muscle fibres, can be demonstrated. In other cases starchy indigestion is present, although fat is always well tolerated. The liver acts well, but excess of mucus is frequently present in the fæces, and occasionally typical mucous casts of the bowel appear. In the fæces the amount of indican varies from very slight to excessively large amounts. It is stated by these writers that the amount of indican depends upon the activity of the colon bacillus in producing putrefaction; whereas, if the quantity of indican is small, the putrefaction is due to anærobic bacilli. The urine of these patients is generally of low specific gravity and copious. If there is no nephritis present, the output of solids is normal, but the amount of indican varies."

Andrews and Hoke fed their patients on cow's milk fermented by the action of the *B. lacticus* and brewer's yeast.[1] The presence of lactic acid increases the acidity in the intestine, limits the activity of the colon bacillus, and therefore prevents putrefaction. In the presence of lactic acid, casein is broken up into small particles, and some of it converted into lactalbumin, hemi-albumose, and peptone, thus facilitating its absorption. As to the amount of the fermented milk, in some cases it may form the single article of diet, and then three to four quarts daily are necessary. In other cases, however, vegetables and a small amount of bread or biscuits are given to vary the diet. It is found that some patients will tolerate milk diet alone for a month or six weeks, and then by allowing a little change it is easy to go back to the fermented milk. It is true that the stools and urine on a fermented milk diet may still show evidences of albuminous putrefaction, yet the toxic effects lessen or disappear. It seems as if the toxins produced by the fermentation of the milk differ in some way in their effect on metabolism from the toxins produced by the putrefaction of meat proteids.

The course of treatment, which I adopt, is to order a saline purgative to be taken every morning for three weeks, just sufficient to cause one liquid motion daily and not to scour. Salol or guaiacol carbonate is also given three times a day after meals in five-grain doses, and the quantity of meat in the diet is gradually reduced, whilst the amount of milk is increased. If the patient has pyrexia from time to time, indicating that toxæmic products are being rapidly formed, I use B. coli vaccine.

At the end of three weeks I substitute Bulgarian fermented milk for the ordinary milk.

The Preparation of Fermented Milk.—Milk may be fermented so as to produce lactic acid by the action of two organisms. Metchnikoff, who introduced this milk to general notice, stated that he obtained an organism from Bulgarian milk or *youghout.* The organism is known as the bacillus of Massol. It was originally isolated and identified in the Pasteur Institute, and its properties have been worked out by Grigoroff and Cohendy. It is entirely different from the other organism, the *B. lacticus.* The bacillus of Massol is like *B. anthrax* in appearance and size. It is seen in long chains, and is very prolific, and its growth temperature is not lower than 94° F., its optimum temperature being 94° to 104° F.—*i.e.*, it grows best at blood heat. It is capable of fermenting the lactose of milk to a complete finish in the form of lactic acid, and, further, has a

[1] It is difficult to see what use brewer's yeast subserves. It cannot ferment the lactose.

slight peptonising action on proteids. The bacillus of Massol should be kept in pure culture, and milk which has been fermented with it can be left exposed to the air for from ten to fourteen days, and will not undergo putrefaction, although organisms of mould will grow in it.

In producing the Metchnikoff milk, machine-skimmed milk must be used, and a pure, fresh, wet culture of the bacillus of Massol is essential. It is curious that while one of the by-products of *B. coli* is lactic acid, yet milk fermented either with bacillus of Massol or *B. acidi lactici* is inimical to colon bacillus. Metchnikoff claims that, for fermented milk to have its full effect on the *B. coli*, it must be treated with both the bacillus of Massol and *B. acidi lactici.*

We have now to speak of the other organism, of the *B. acidi lactici* or the *Streptococcus Guntheri.* Ordinary sour milk is due to this organism, and its optimum temperature is 75° to 85° F. In the preparation of the milk by *B. acidi lactici*, a simple way of starting the process is to put a piece of hard cheese in boiled milk, and let it stand at a temperature of 80° for twenty-four to forty-eight hours. The first product is thrown away because of the presence of other organisms, but a small portion is retained for starting the process in a second lot of freshly-boiled milk, and so on till a pure culture of *B. acidi lactici* is obtained. This is never so acid as that formed when bacillus of Massol is used, and, indeed, it is necessary in the latter case to dilute the excessively acid product with an equal quantity of freshly-sterilised skimmed milk. Fermentation with the bacillus of Massol may be induced in whey, and this is a great point, as many patients complain of the fattening effect when milk is used.

We have, therefore, two products before us—the Metchnikoff milk and the *B. acidi lactici* milk. The latter is efficacious, the former still more so.

The therapeutic effect of fermented milk is increased by adding a teaspoonful of powdered cane-sugar to it. Numerous preparations, said to contain the ferments in a dry form, are on the market, but many have lost their fermenting properties in the drying process, and discrimination is to be used in advising them. Some patients, too, are very surprised to find the curdled milk does not help them with a diet of roast beef. Others suffer from severe diarrhœa and discomfort when taking it, and are compelled to cease doing so.

Many sufferers cannot be kept entirely on the fermented milk diet for any length of time, but occasionally must have fish or white meat. The effect of these articles of diet should be carefully watched and the condition of the joints noticed. We can then decide whether to allow more proteid food, or go back for a time to the milk.

Andrews and Hoke[1] quote five cases *in extenso,* where the joint

[1] *Amer. Jour. Orth. Surg.* vol. v. No. 1, July 1907, p. 61, *et seq.*

symptoms improved in the most remarkable manner. Pain and fermentation disappeared, the temperature fell to normal, the patients gained weight, and were able to use the affected joints without difficulty. In our own practice we have had similarly gratifying results. It is too soon to be able to affirm that the disease is permanently cured, but it has been checked, and great relief has been given. It appears to us that patients require from time to time a course of treatment on the lines described. At any rate the outlook is hopeful, whereas until a few years ago there was no disease which was regarded as so hopeless as arthritis deformans.

The question of taking alcohol is often raised, and we have advised that champagne, spirits, hock, and bitter ale should be avoided. The red wines of Burgundy and Bordeaux and good English stout may be taken in some debilitated cases, but even after a very small quantity of alcohol many patients say that they find a distinct increase of heat and pain in the joints.

With regard to clothing, woollen underclothing is the only kind permissible, even in summer. These patients are liable to perspire on slight provocation, and become easily chilled, so that this kind of clothing is essential.

Concerning exercise, due regard must be had to the situation of the joint or joints attacked and the stage of the attack. Thus no one would advise a patient with a subacute arthritis to take a large amount of walking exercise; although, as it is advisable that the free action of the skin should be promoted, general massage and the judicious use of hot baths are called for.

So soon as the pain and tenderness have ceased, the joint should be gently used, the amount of use being regulated by the patient's experience. If he finds that a given degree of movement brings on the heat and pain, then he is put to rest for two or three days, after which he should resume exercise to a less degree. In the quiet stage gentle massage is valuable, but the usual mistake is made of too vigorous and prolonged movement.

As to drugs, those which we have found apparently to be of service are guaiacol carbonate, iron with arsenic, and sometimes Donovan's solution. In the subacute stage of the disease, and when the joint is swollen and tender, with the fine crepitations mentioned on page 443, carbonate of guaiacol is very useful, particularly if there is a strong tuberculous history in the parents. When the joint symptoms begin to lessen, and the fine crepitation is replaced by the coarse crackling, we find that arsenic or arsenic and iron, or Donovan's solution, is better. Cod-liver oil is often borne well by these people, but iodide of potassium is generally too depressing.

P. W. Nathan,[1] in his contribution to the study of metabolic "Osteo-Arthritis," says he has had uniformly good results with the use of thymus gland extract. He begins with two five-grain tablets twice daily. In two weeks the dose is increased to three tablets, and after a few months three tablets four times a day are given. The patient is kept at rest until all symptoms of active joint disease have passed, and then passive movement is begun.

In fact the general treatment of rheumatoid arthritis may be *summed up* thus:—Diminish fatigue of every kind in every way, correct errors of metabolism, increase the general nutrition, feed appropriately, and give such drugs as seem to suit the patient.

Local Treatment.—Inasmuch as the disease is a degeneration rather than an inflammation, the nutrition of the tissues in and around the joint must be improved, and all causes of undue strain avoided.

Rest to the Joint.—Under no circumstances is the joint to be absolutely fixed. Support rather than fixation is called for. When the part is painful, tender and very irritable, a splint or some retentive apparatus should be applied after the joint has been firmly compressed by layers of cotton-wool and an elastic bandage. It is found that Geneva crêpe bandages are better than elastic rubber ones. The splint and bandages should be taken off at least once in the twenty-four hours to allow the joint to be moved gently, for hot douching, and, if it gives relief, gentle massage. When the painful signs have subsided, the splint may be discarded, whilst the elastic support is retained.

Much of the tenderness of the joints can be relieved by small blisters or painting the part with a preparation of iodine twice the strength of the ordinary tincture. Sometimes extract of belladonna and glycerine will soothe a very irritable joint, and oleate of morphia, mesotan, and ichthyol ointment are useful. However, the physical and electrical methods to be described presently are often more efficacious.

Balneological Treatment.—The places in this country which enjoy a deserved reputation are Buxton, Bath, Droitwitch, Woodhall Spa, and Strathpeffer; while abroad Aix-les-Bains and Brides-les-Bains are among those to which such patients are sent. It is

[1] *Amer. Jour. Med. Sci.*, June 1909.

difficult, however, to say how much of the improvement in the general and local conditions is due to the chemical constituents of the waters and how much to the local manipulations, and above all to the absence from work and worry, the fresh air, the pleasant surroundings, and the regular mode of life and avoidance of fatigue. At home, alternate douching with hot and cold salt water often affords relief in the congestive stage.

Bier has treated the knee, ankle, elbow, and wrist by passive congestion on similar lines to tuberculosis, and he has obtained good results both by active and passive hyperæmia.

Other local measures remain to be spoken of. Thus, if there be much fluid present, Wohlman recommends aspiration of the distended joint in the acute stage.[1] Buedinger[2] uses sterile vaseline in chronic forms of arthritis. He injects 1-4 c.cm. into the knee, and less into small joints. The pain and reaction last two to six days, but he says the ultimate result is good.

Physical Treatment, meaning massage and manipulations and the application of heat. Massage by the hand is often useful, particularly in the chronic stages. As a rule, in the acute and subacute conditions the joint is too tender. Rapid vibratory massage is generally of as much, if not of more service, than the manual form, and is applied over the affected joint and the spinal column. At first the pressure is light, and as the joint becomes less boggy it is firmer. When defects of digestive metabolism are evident, vibratory massage is used over the abdomen.

Heat is applied either by douching with hot water, by hot salt packs, by hot sand packs, or by radiant heat, the efficacy of the first being the least, and of the last the greatest. A. P. Luff thinks highly of radiant heat in obstinate cases of arthritis deformans, although discretion must be exercised in its employment. If it is found to be fatiguing to the patient, it should be stopped.

Electro-Therapeutical Methods comprise the electric light bath, the static wave current, the static indirect spark, the static "breeze," the high candle power light, and ionisation.

The *electric light bath* is used either generally or locally. The theory underlying the use of the electric light bath is that of radiant heat. If the source is electric, the rays are supposed to penetrate deeper than when the heat is derived from a Bunsen burner, an oil or spirit lamp; certainly the temperature of an

[1] *Brit. Orth. Soc. Trans.* vol. iv.
[2] *Wien. klin. Wochenschr.* No. xvii.

electric light bath, producing the same effect as the hot air, is much lower. The duration of a general electric bath should not exceed fifteen minutes. If it is longer, a feeling of lassitude follows. After every form of radiant heat, the patient should, if fairly strong and vigorous, take a tepid bath of 85° or 90° according to the external temperature, and in winter the bath should not be lower than 90°, otherwise the shock is too great. He remains in it for three or four minutes, just sufficient for the necessary reaction, and then rubs himself briskly with a rough towel until he glows. Dressing is to be carried out leisurely. If hurried, perspiration results, and he may take cold on going out of doors. Less vigorous patients content themselves with a tepid sponge bath and a good rub down.

The electric light bath [1] is arranged with one hundred sixteen candle power incandescent lamps, and either a chair or, better, a couch is used, so that the patient, entirely nude, is in the reclining position with the head outside the cabinet. The lights are controlled by a "dimmer," so that the entire field of light may be regulated from a slight glow to a maximum of intensity. The patient's head is kept cool and free from congestion by a cold wet towel, an ice-cap, or an electric fan. Perspiration begins in five to seven minutes, and later profuse sweating, which usually occurs when the temperature of the bath is 50° to 55° C. The error generally made is to continue the bath too long, so that patients feel weak and tired after it. A bath of fifteen minutes twice or three times a week is sufficient.

According to F. E. Peckham, "the swollen and boggy joints begin to diminish in size, the thickening to disappear, and the stiffness and pain to be forgotten. The improvement is slow, but the results are gratifying in the majority of cases."

The electric light bath can also be used locally, but it is not so satisfactory as the "all-over" bath, or even as the high candle power light.

For the description and practical details of other methods of electro-therapy I am indebted to my friend Dr. Howard Humphris, who has kindly furnished me with the following notes:—

"No apology is needed for any suggestion that can be made in this malady, which is still classed by many as an incurable disease. It is a fact familiar to many workers in the field of electro-therapy that most of these cases can be relieved, and the course of the disease be arrested by one or other of the different forms of electricity. Atrophic arthritis is associated with mal-nutrition and faulty metabolism, while the rationale of most forms of electric currents is that they improve nutrition and conduce to healthy metabolism. Before the joints are affected there is a stage, more or less prolonged, during which obscure but profound mal-

[1] F. E. Peckham, *Amer. Jour. Orth. Surg.* vol. v. No. 4, p. 409.

nutritional changes are taking place. If it is possible for the disease to be treated before the joints are affected, I believe that the secondary effect can be prevented. As a rule, it is the pain in the joint which leads the patient to seek advice, and it is primarily due to stasis and congestive infiltration. The application of electricity is of great benefit in this stage and whilst alterations are taking place in the softer structures. When the peri-articular and synovial tissues are undergoing thickening, the static wave current, surging through them, relieves congestion and lessens the thickening. Even later on, when the atrophic stage is reached, the minute vibratory action of this current improves the nutrition of the parts, retards and arrests the disease.

"In using static currents it is essential to have a sufficiently powerful machine. Much of the adverse criticism to which static electricity has been subjected may be traced to the fact that many workers have used, and are using, insufficient and feeble machines. The technique of the application of the static wave current is as follows:—A piece of sheet tin is bound firmly over the painful area, or over the spine as the case may be, and is connected to the positive side, the negative side being grounded. The sliding rods of the machine are gradually opened as far as the tolerance of the patient will permit. The static machine should be capable of a 10-inch spark-gap, and the metal electrode is at least 150 to 200 square centimetres in area. Whilst the current is passing, tissue-contraction is induced, and the muscles can be seen vibrating. All the soft tissues are thus affected, so that it is not difficult to understand why the current should cause diminution in the quantity of fluids in the infiltrated area, and lessen or relieve the stasis upon which the arthritic condition depends. It is probable that healthy cell action is thus induced and lively physiological activity replaces pathological torpor.

"The static indirect spark (very different in its action, be it noted, from the high frequency spark) acts in a similar but more energetic manner. Here, the negative side of the static machine is connected with the insulated platform by means of a brass rod, and the sliding rods are widely separated. The static machine is then started, and sparks are taken from the patient's body by means of a brass ball attached to another grounding. The spark should be from 4 to 8 inches in length.

"There is also the static 'breeze' which is useful in rheumatoid arthritis, more especially when the pain is very acute. Here, the connections are as for the indirect spark, but the brass ball is replaced by a stick of white wood which must not be too dry. This is brought near the affected joint, and a blue light is seen passing from the joint to the wooden stick. In appearance it is like the high frequency *effleuve*, and the patient experiences no unpleasant sensation, merely feeling a breeze about the parts.

"There are other forms of electricity besides those derived from the static machine which may be used with advantage in arthritis deformans, and chief among them I would mention electric light. A single lamp of high candle power is most useful, especially as a prelude to the administration of static electricity. Professor Bier [1] remarks, 'in chronic articular rheumatism, in arthritis deformans, in acute rheumatism, active hyperæmia produced by hot air is principally indicated.' By the use of the high candle power incandescent light we obtain an active hyperæmia, and I have found it to be superior to that produced by heat without light, not only in giving immediate subjective relief, but the effects also appear to be more lasting. Why this should be so is difficult to say, unless it is directly due to cell stimulation from actinic effect. The light, it has been my habit of using, is an ordinary incandescent lamp of 500 candle power, surrounded by a bright metal reflecting hood. This is slowly swayed to and fro over the affected joint or joints for twenty minutes to half an hour, holding it as near to the patient as the heat will permit. At the end of this time the skin is somewhat reddened, and the pain is as a rule much less. The improvement will be prolonged if the application of the electric light is immediately followed by either the static wave current or by the static spark.

"Another measure which is often of much use is Ionic Medication by means of the galvanic current. It is especially indicated where there is a boggy swelling around the joint. The technique is as follows:—Make a 2 per cent solution of sodium chloride in sterile water. The joint may be immersed in this, or wrapped round with some twenty thicknesses of absorbent lint, which has been saturated with the solution. A piece of tin-foil is then firmly bound on to the lint, covered with oiled silk and connected with a wire to the negative side of the battery. If the limb is immersed in the salt solution a wire leads from the solution to the pole. Everything should be firmly attached, the bandage secure, and close contact made at all metallic junctions. This is the active electrode. The indifferent electrode may be placed anywhere upon the patient's body, but it should have a larger superficial area than the active or negative electrode; it may be similarly made and wrapped round the leg, or a hand or foot or leg may be immersed in water; connection is made with the positive pole, and again all contacts should be examined and made perfect. Everything now being in readiness, the milliamperemeter and rheostat being in circuit, the current is turned on. The rheostat is gently, slowly, and evenly moved, and the current flows, the amount passing being carefully noted on the meter. The importance of increasing the current slowly and evenly cannot be overestimated. In estimating the dosage at any one sitting, the sensations of the patient are the best guide. Theoretically, it should not exceed 5 milliamperes to the sq. cm.; but, practically, the current strength is only limited by the patient's toleration, which is usually very much less than this. The treatment ought to be painless, and when discomfort is felt, the rheostat is turned gently and slowly back to that point at which the patient says he is comfortable.

"The current registered by the meter will naturally vary in direct proportion to the size of the electrode. To give a general idea, however,

[1] *Text-Book of Hyperæmia*, London, 1909, p. 396.

if the fingers of both hands are covered by the electrode, the current, cautiously increased, will usually be well borne up to 30 milliamperes. Larger areas will, of course, allow larger currents, and cases are recorded of patients who after the first twelve minutes could tolerate 100 milliamperes without pain.

"The treatment lasts about thirty minutes, and is continued thrice weekly, decreasing the frequency of the applications *pari passu* with the improvement brought about. From the first, the patient observes increasing freedom of movement, lessening of the stiffness of the joint, and in many of the painful varieties of arthritis, a diminution of the pain. The chlorine ions are thus forced through the skin and into the sclerosed tissue. Ankylosis is relieved by bringing about resolution, and the joint regains its freedom of movement. Dr. A. Caries presented an exhaustive study of this current in arthritis in his *Bordeaux Thesis*, January 1905. Yet another electro-therapeutic measure which has given great relief both in rheumatoid arthritis and tuberculous arthritis is the application of X-rays. In the hands of some physicians very excellent results have been obtained. Great care is required not to burn the patient. This risk is avoided by filtering the rays and excluding the α-rays.

"The use of electricity in joint affections is no new thing. Among the first observers to use electricity in the treatment of joints was R. Remak, 1856. Later Danion (*Traitement des affections articulaires par l'électricité*, Paris, 1887, p. 338) was successful with this therapeutical measure. Leduc, in *Arch. d'électricité médicale*, 1894, p. 478, and in subsequent writings, describes in scientific detail his personal success in the treatment of arthritis by electricity. C. Leo V. Marino, M.D., *Australasian Medical Gazette*, July 1890, reports several cases of arthritis treated by electricity, and says: 'In subacute and chronic cases, whether of rheumatism or arthritis deformans, in stiffness of the joints following sprains, dislocations, or fractures near the joints, in periarthritic swellings, and the like, electricity stands unrivalled.' Dr. G. W. Gwyer, in an article on the treatment of fibrous ankylosis in the *Annals of Surgery*, August 1893, gives an account of the use of the galvanic current in the treatment of several cases. The pain was immediately relieved, the range of motion increased, and part of the fibrous tissue absorbed.

"It is impossible to lay down general rules for treatment in any particular case. Each case may differ in cause, in general health, or in the degree of the local affection. All of them must receive careful consideration and individual treatment."

The Surgical Treatment of Arthritis Deformans [1]

We shall discuss this aspect of the subject under two headings, viz. the surgical treatment of hypertrophic arthritis (osteo-arthritis) and of atrophic arthritis (rheumatoid arthritis). The distinctions

[1] See also A. H. Tubby, *Lancet*, 1908, vol. ii. p. 1865, and *Clinical Jour.*, Oct. 1911.

between the joint changes are so clear, the type of patients in which they occur are so different, that discussion under these headings will traverse most of the surgical field, which is limited at present, although steady advance is being made. Until quite recently the treatment of these distressing and disabling affections was almost entirely in the hands of physicians, who frequently relieved pain and obtained some slight improvement in the movements of the joints. But, when deformity occurred, no attempt was made to arrest it at its inception. It was regarded as inevitable, and the sufferer was only to be pitied, and could not be helped. It has been shown that by surgical measures much of the deformity can be relieved, and joints almost, if not entirely useless, restored to varying degrees of functional activity.

The Surgical Treatment of Hypertrophic Arthritis.—This disease is largely an intra-articular affection, characterised by lipping of the cartilages, development of intra-articular osteophytes and spurs of bone, widening and distortion of articular sockets, and malformation with absorption and destruction of other component parts of the joints. The sufferers are usually advanced in years, often showing signs of arterio-sclerosis, and therefore are not usually suitable for any operative procedures of magnitude. However, they are not to be regarded as hopeless.

We must not confuse the elements of deformity. Some of it is due to the changes within the joint, and some to extra-articular contractions from long-continued malposition. In all cases stereoscopic X-ray photographs should be taken to ascertain the condition of the joint, and the nature and size of the obstruction. An opinion can then be formed as to how much of the deformity is due to conditions within, and how much to those without the joint. To give an example, a patient is seen with a partially stiff hip, in which all the movements are limited, and the X-rays reveal very little alteration of the bony structures, probably a small osteophytic outgrowth on the upper and posterior part of the periphery of the acetabulum, with a slight lipping of the margin of the head of the femur, which are insufficient to account for the almost total loss of abduction. Further examination is made, and the adductors of the thigh are found to be contracted. Section of them often permits painless abduction to 30°-40°. This is a simple example of the necessity and utility of clearly defining the elements of deformity. Similarly, adduction is partially limited by contraction of the muscles arising from the anterior superior spine and of the glutei muscles. The former can easily be severed, and the latter be gradually stretched by weight-extension properly applied. In the same way the flexor contraction is dealt with.

Therefore the first procedure is to overcome the contractions of the muscles, tendons, and fasciæ by weight-extension, tenotomy, and myotomy.

The second point is to endeavour to diminish the pain within the joint, itself a cause of reflex-contraction, and to lessen the irritation due to the contact of inflamed and denuded surfaces of bones. One fact stands out conclusively. No attempt is to be made to increase the range of intra-articular movement by forcible measures. The results always are increased pain and diminished mobility.

Fig. 247.—Arthritis Deformans (Atrophic) of the right knee, with Genu Valgum (A. Schanz).

The procedure adopted by the author when the pain is not extreme is as follows:—An X-ray photograph is taken. The patient is then asked to submit to an anæsthetic for the purposes of ascertaining the range of movement of the joint, and to permit section of the shortened extra-articular structures. After dividing them, the joint is *gently* moved so far as it will go without force, and the range of mobility noted. This is the degree which, at least, we hope to attain by our subsequent treatment. The immediate after-treatment consists of weight-extension to the limb on the inclined plane according to the method of Professor Howard Marsh in tuberculous coxitis, the limb being abducted or adducted as the case may be. The object is to diminish friction between the joint surfaces. It is the keynote of future treatment. After several weeks in bed the movements of the joints, though still limited, will be found somewhat increased, and are now painless. When the patient is allowed to get up, he uses crutches with a patten on the foot of the sound leg. The movements of the affected limb are safeguarded by an apparatus with a pelvic band, and continued down to the boot on the inside and outside of the leg. In fact, a Thomas' calliper knee-splint with a pelvic band and a locking arrangement opposite the hip-joint, which allows movement within the painless limit, is the form we adopt. After a time the crutches and pelvic band are dispensed with, and the inner part of the groin-ring of the splint is thickened so as to form an ischial crutch, transmitting the weight of the body directly to the boot and preventing pressure within the hip-joint. The amount of walking is increased, provided that no pain is caused. In marked cases it is advisable to continue to use the weight-extension at night; and the inclined plane is now no longer necessary, because the flexion deformity has disappeared by this time.

We have had encouraging results with treatment on these lines. One of our patients—a record athlete in his time—was seen when he was unable to move without pain, and the movements of the hip-joint were limited to a few degrees. After six months' treatment he was able to enjoy salmon-fishing, and has even walked five miles a day. The arc of movement now varies from 40° in flexion and extension to about 30° in abduction and adduction, and he is free from pain.

Hypertrophic affections of the knee are treated on the same lines, when some movement is found to be retained; much deformity may thus be removed. Still, there is another side to the question: correction of deformity is sound, but still more sound is prevention. The latter fact is generally disregarded.

Intra-articular interference is rarely justifiable in hypertrophic arthritis. If it be done with the object of removing bony outgrowths, except the smallest, from the edges of the cartilages in order to secure more free movement, then experience shows it to be far from satisfactory. Nevertheless, when many loose cartilages are present in the knee, aggravating the swelling and pain, it is justifiable to operate. We have also on two occasions seen, by X-ray examination, a bony outgrowth from the posterior part of the acetabulum, or head of the femur, so placed as to cause increasing pain from pressure on the sciatic nerve, particularly when the thigh was flexed. In such cases we have felt it right to recommend arthrotomy for removal of the spur.

At the knee, bony ankylosis in a bad position will bring *caeteris paribus* the question of excision, wedge-shaped or otherwise, into serious consideration. And, at the hip unrelenting pain may force us either to excise the hip or to undertake an osteoplastic operation. Osteoplastic methods are recommended by R. Jones [1] (see Ankylosis). Albee [2] of New York, recognising that friction within the joint is the cause of pain, ankyloses the hip in an abducted position. After section of the adductors, he opens the joint and removes the upper hemisphere of the head in a line with the axis of the neck, and deals with the acetabulum so that a flat roof is formed, which fits the flattened surface on the head of the femur.

The Surgical Treatment of Atrophic Arthritis.—The objects are :—

1. To prevent and correct deformity.

2. To remove from the articulation the products of inflammation due to bacterial action or to toxins. In this connection it is interesting to note the great improvement which takes place in the joints generally, even after opening and draining one of them. It appears as if the lessening of the total quantity of toxins has a beneficent effect upon the general condition.

3. To excise hypertrophied villi, and remove obstructions which limit the movement of the joint, increase the quantity of effusion, and produce erosion of the articular surfaces.

The Prevention and Correction of Deformity.—Malposition of the part when the joint is at rest can be avoided by using splints ; or, if a joint such as the knee is very painful, by rest and weight-extension, until the subacute symptoms have subsided. If contractions have occurred, and if it is found that ordinary physical and electro-therapeutical measures, with rest and weight-extension, are not giving satisfactory results, then we must act more vigorously.

In the atrophic forms, the extra-articular changes are greater from the first than the intra-articular, so that contracted fasciæ, tendons, and muscles are largely responsible for the deformity. All shortened bands are divided. If the joint remains deformed, then gentle attempts are made to straighten it. Where many joints are affected, only those should be dealt with, which seriously interfere with locomotion, or are markedly deformed ; and no straightening efforts should be made if fluid is present in the joint.[3]

In attempting to mobilise a joint, which is the site of atrophic arthritis, no force is to be used, for we must recognise that we are

[1] "Surgical Treatment of Rheumatoid Affections," *Brit. Med. Jour.* vol. ii., 1909, p. 3.

[2] *Jour. Amer. Med. Assoc.*, June 13, 1908, and *Compte rendu, XVI. Internat. Med. Congress*, Section vii., *Orthopédie*, Fasc. ii. p. 161, Buda-Pesth, 1910.

[3] *Trans. Brit. Orth. Soc.* vol. iv.

dealing with bones rendered weak and fragile by degenerative and rarefactive changes. If it seems that much effort will be required to straighten the joint, then it is better to desist; and, provided that the obstructions in the extra-articular tissues have been dealt with, we may open the joint and examine it.

After manipulation of the joint, it is always advisable to place the part at rest, either on a splint or to apply weight-extension until the effects of the disturbance of the joint have subsided; and later, in walking, a splint is worn, so contrived that whilst movement is permitted, the body-weight is taken off the part. At the hip this can be done by a Thomas' calliper knee-splint, with the ring at the inner part of the upper end of the apparatus, thickened so as to transmit the weight of the trunk from the tuber ischii directly to the boot, and so to the ground. At the knee, the Thomas' splint is used at first; and extension is applied to the limb by traction from a stirrup on the leg and foot to the transverse bar joining the lower parts of the splint. When the patient walks, the calliper-splint may be used, and by a regulated joint opposite the knee, movement within the painless range allowed. Gradually the movement increases, and now that friction and weight-pressure are no longer effective, the joint diminishes in size and increases in usefulness.

Arthrotomy serves to drain the joint and enables us to remove obstructions within it. Considerable work has been done in this direction by C. F. Painter and W. J. Erving,[1] Goldthwait, J. Elter,[2] E. H. Bradford,[3] Collinson,[4] Bannatyne,[5] Southam,[6] and Howard Marsh.[7]

When fluid is excessive and persistent, aspiration is recommended as a tentative measure. If it is not successful, the joint should be laid open and washed out with normal saline lotion and drained. A free incision into the joint affords an opportunity of thorough examination and removal of the causes of obstruction. They are hypertrophied synovial folds, overgrown and pedunculated villi, rarely osteophytes, and occasionally masses of thickened sub-synovial tissue, such as are seen behind the ligamentum patellæ, and

[1] *Boston Med. Surg. Jour.*, March 1903. Also C. F. Painter, "The Place of Operative Surgery in the Treatment of Chronic Arthritis," *Amer. Jour. Orth. Surg.*, 1908, vol. v. No. 4, p. 413.

[2] *Deutsche Zeitschr. f. Chir.* lxvi.

[3] *Trans. Amer. Orthop. Ass.* vol. xv., 1902.

[4] *Lancet*, Nov. 4, 1899.

[5] *Ibid.*

[6] *Lancet*, Dec. 9, 1899.

[7] *Lancet*, Nov. 18, 1899.

cause thickening of the synovial folds of the ligamentum mucosum and ligamenta alaria. With incisions of sufficient size and properly placed, bearing in mind that our object is to secure increased mobility, these obstructions are removed, and the joint is restored to a very fair degree of usefulness. We have frequently opened the knee-joint and carried out this procedure. With careful after-treatment, the results have fulfilled our most sanguine expectation so far as recession of the disease and local improvement are concerned.

Before operating, it is advisable to take an X-ray photograph of the joint so as to determine the position and nature of the obstruction to free movement.[1] Removal of the synovial membrane is done with judgment, and care is taken not to interfere too freely with the actual articular surfaces. Experience can alone dictate the amount of excision of soft tissues.

Speaking of the removal of hypertrophied villi, Painter and Erving[2] add, "This procedure is not ordinarily accompanied by any recurrence of the villi, because the cicatrisation of the denuded portion of the capsular surface causes the entire membrane to shrink, and scar-tissue does not readily lend itself to villous hypertrophy." In several recent cases operated upon by them, immobilisation was not practised after the operation, and no splints were applied, but merely soft dressings. The amount of effusion was not greater under these circumstances. The patients did not seem to have more discomfort, and the movements returned more quickly. They rightly insist upon the importance of post-operative treatment. Passive manipulation must be carried out by the surgeon, and active movements by the patient daily during the second week. Post-operative stiffness seems to vary with the size of the pedicles cut across. Thus a vascular fringe with a thick pedicle leaves a broad denuded surface. The adhesions are, however, readily overcome in most patients without an anæsthetic. These writers speak enthusiastically of their results.

In those cases where severe crippling has taken place, and especially where joints have become immovably ankylosed in faulty positions, excision is called for, or an attempt may be made to form a new joint.

[1] R. Jones, *Brit. Med. Jour.*, 1909, vol. ii. p. 3, points out that "distension of the joint with oxygen (with scrupulous care) renders the picture on the plate much more instructive."

[2] *Amer. Jour. Orth. Surg.*, 1908, vol. v. No. 4, p. 413 *et seq.*

One of the most troublesome situations in which arthritis occurs is the temporo-maxillary articulation. Tenderness is often excessive, and radiating pains of a neuralgic character are present, which are increased by movements of the jaw in eating and talking. If the ordinary palliative measures fail, and if ankylosis results, it is advisable to form a new joint in the vertical or horizontal ramus on the lines laid down by Huguier.[1]

To sum up the treatment of atrophic arthritis, ascertain the cause of the joint affection, remove all conditions of septic or putrefactive origin, use vaccines if required, and treat the general health in such a way as to diminish all causes of wear and tear. Locally, give a requisite degree of functional rest and relief from weight-pressure to the joint; stimulate nutrition by physical and electro-therapeutical measures. If deformity exists, correct it; open the joint and excise all obstructions, where it is evident that progress is being delayed, and be very assiduous in the after-treatment.

If the disease be attacked on these lines, much suffering and crippling will be avoided, and many patients restored to a state of usefulness and comparative comfort.

[1] *Traitement des ankyloses,* Paris, 1905.

CHAPTER II

SPONDYLITIS DEFORMANS

Ætiology—Bechterew and Marie-Strümpell Types—Pathology—Symptoms—Diagnosis—Treatment.

VERY many synonyms have been applied to this condition: *Spondylarthritis deformans, Rheumatoid arthritis of the spine, Osteoarthritis of the spine, Bechterew's disease, La spondylose rhizomélique of Pierre Marie, Malum senile.*

It appears certain that more than one pathological process is involved. The leading features are chronic stiffening and eventually ankylosis of part or of the whole of the vertebral column, features common not only to cases of spondylitis deformans proper, but also to the rheumatic, gouty, gonorrhœal, and the senile spine.

Ætiology.—As to the causation of rheumatoid arthritis of the spine we refer the reader to the remarks on the ætiology of arthritis deformans in general, but a few words may be said here on the causation of the whole group of cases of spinal disability, characterised by chronic stiffening. Pathological findings demonstrate without doubt that arthritis deformans may lead to ankylosis in the spine, and, if the patient shows definite signs of the disease elsewhere, there is no difficulty about the ætiology. The opinion of those most qualified to judge is that arthritis deformans does actually account for the greater proportion of these rigid spines; also that disease probably covers the Bechterew type, if one accepts Bechterew's contention that such a definite type exists,[1] and certainly covers the type described by Pierre Marie,[2] which is substantially the same as that portrayed by Strümpell.[3] Probably many or most

[1] "Steifigkeit der Wirbelsäule und ihre Verkrümmung als besondere Erkrankungsform," *Neurologisches Centralblatt*, 1893. Also *Deutsche Zeitschr. f. Nervenheilkunde*, Bd. 11, 1897; Bd. 15, 1899.

[2] "La Spondylose rhizomélique," *Revue de méd.*, 1898, and *La Semaine médicale*, 1899.

[3] Strümpell, "Bemerkungen über die chronische ankylosierende Entzündung der Wirbelsäule und der Hüftgelenke," *Deutsche Zeitschr. f. Nervenheilk.* Bd. 11, 1897.

of the senile cases are rheumatoid or osteo-arthritic, and here the static factor also comes into play.

Gonorrhœa, just as it may cause fixation and even complete ankylosis of joints of the limbs, may give rise to a spondylarthritis with more or less subsequent ankylosis; and, much as one must beware of the *post hoc* fallacy, a considerable number of undoubted cases have been reported.

A small number may be accounted for by gout and chronic rheumatism, the sequence being spondylarthritis, fixation, ankylosis; it is notorious how readily ankylosis follows on spinal fixation.

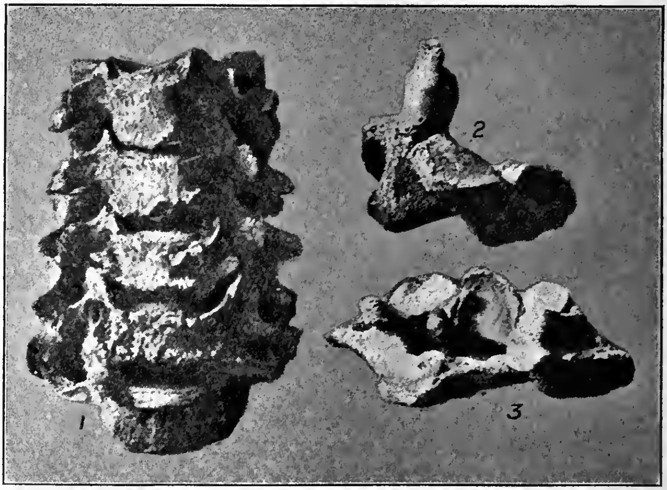

FIG. 248.—Spondylitis Deformans, co-existing with Arthritis Deformans, observed in a body from Egypt, interred 5500 years ago (W. Page May).

Heredity, trauma, and exposure to wet, cold, and changes of temperature play a part. The onset of acute pain and fixation often follows a fall, a wetting, or undue exposure; and, after the widely spread spinal distress subsides, more or less extensive permanent rigidity is found.

It is possible that many of these factors act by setting up a liability to spondylarthritic changes.

Males are more frequently attacked than females, perhaps because they are more subject to the secondary causes mentioned above; and early adult life appears to be the age at which the onset is usual, a fact which possibly has given rise to over-estimation of the gonorrhœal factor. No age, however, is exempt. It has been seen in a child of 10 years (Royal Whitman), and a certain amount of osseous fixation is practically the rule in old age.

Pathology.—The *first stage* is often lipping of the margins of the bodies and production of osteophytes. They may limit movement, and eventually coalesce and ankylose. Goldthwait states that the process usually begins upon one side anteriorly, and extends up and down the outer fibres of the anterior ligament, and that the chief deposit or new formation of bone is along these lines, the change in the middle line consisting simply of a fusion of the vertebræ.[1] The deposit may spread over a few vertebræ only, over the whole spine, or be in the form of separate patches. Thus, in a specimen in the writer's possession there is a patch in the upper dorsal region; below this, down to the eighth dorsal, the vertebræ are either healthy or show deforming arthritic changes, but are not ankylosed. The eighth to the eleventh dorsal are ankylosed firmly. The bony deposit is on the right side of the anterior ligament, and just overlaps the left of the median line. Viewed from the left side, the vertebræ look almost normal, save that the discs are atrophied and ossification of the interspinous and subflava ligaments is seen,

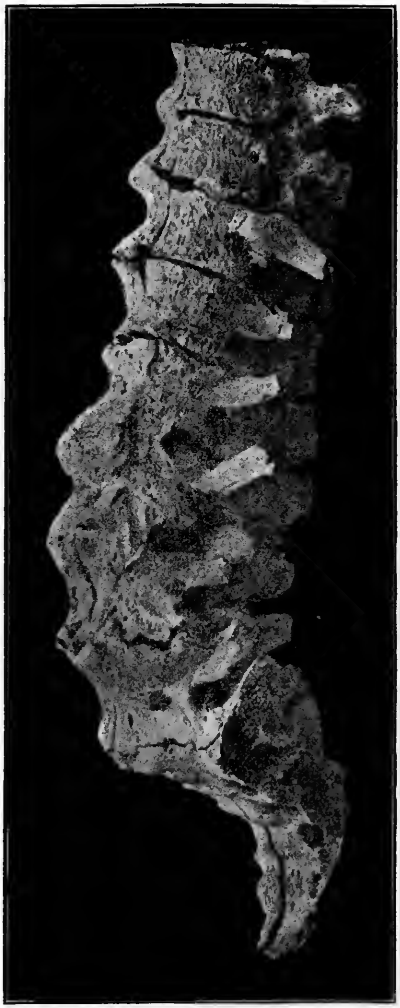

FIG. 249.—Spondylitis Deformans and Spondylarthritis Ankylopoiëtica (L. Wullstein, from the Virchow Museum, Berlin). The specimen was taken from a man, aged 39 years. The intervertebral discs are partially or entirely absorbed, the anterior ligament is ossified, the lower lumbar vertebræ are ankylosed, and large osteophytes have formed, especially on the front of the bodies of the last two lumbar vertebræ.

[1] Goldthwait, "Osteo-Arthritis of the Spine," *Trans. Am. Orth. Ass.* vol. xii.

whilst in front the left edge of the bony deposit in the anterior ligament appears. Viewed from the right side a smooth deposit of bone is seen on the right side of the anterior ligament. This is raised into smoothly rounded bosses opposite the intervertebral discs. The appearance is well described by a simile of Schlesinger, as being as if molten sugar had been poured over the part. In this specimen the 8th, 9th, 10th, and 11th dorsal vertebræ are thus solidly splinted together. The ligaments between the spines

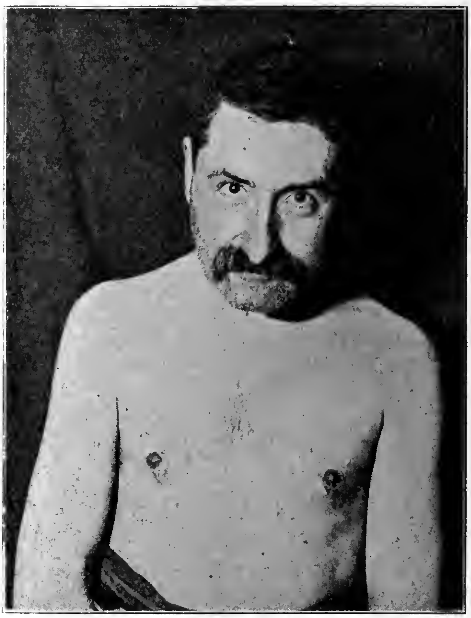

Fig. 250.—Spondylitis Deformans, previous history of gonorrhœa. From a man aged 43 years, under the author's care at Westminster Hospital.

and lamellæ are ossified, especially between 10th and 11th dorsal. The articular surfaces are not ankylosed, but there is a fairly developed peri-articular deposit of bone between the 10th and 11th dorsal vertebræ, such as would before long lead to complete ankylosis and obliteration of the joints. In places, the new deposit of bone has encroached on the intervertebral foramina, especially by filling in the notches above the transverse processes. This last observation, in view of the nerve-symptoms, is of great importance. There is little deformity, but the shrinkage of the discs tends to cause kyphosis. Although in this specimen the bodies are not deformed, it can readily be conceived that the shrinkage of the discs may give rise to such static conditions that, acting in combination with rarefactive and atrophic changes, the marked wedge-shaped deformity seen in certain specimens may be accounted for.

By the changes described, not only may the whole spine be transformed into a rigid rod, with perhaps more or less kyphosis, or in some cases scoliosis superadded; but also if the costo-vertebral

Fig. 251.—Lateral View of the patient seen in Fig. 250.

joints become ankylosed, the spine and ribs are as if carved out of one solid piece, so that respiration must be purely diaphragmatic.

Symptoms.—The leading symptom is the bony rigidity of the segments involved, perhaps of the whole spine. Occasionally, the spine retains its normal curvature, but more often a definite and marked kyphosis is present, and sometimes a lateral curve.

The onset may be insidious, or it may be ushered in by an acute attack of spinal tenderness, at first widely spread, but eventually subsiding, and leaving more or less extensive ankylosis behind.

The spine alone may be affected, or signs of ankylosis may be present in other joints as well. Thus, in a patient figured by Wullstein, the spine and all the joints were fixed, save the left shoulder and toes. Yet, in this case no joint was deformed, and in none could creaking, grating, or effusion be demonstrated.

In addition to the tenderness in the back, limited movement and fixation by muscular spasm are seen at an early stage. In some

Fig. 252.—Spondylitis Deformans in a man, aged 48 years, under the author's care in Westminster Hospital. The hips and the knees were also affected by arthritis deformans.

cases painful symptoms of quite another type arise as time goes on. They are neuralgia, areas of hyperæsthesia or of diminished sensibility, and paretic or even paralytic symptoms. They are due to pressure on the nerve-roots, set up by deposits taking place in the intervertebral foramina in the manner we have mentioned above. Eventually, as the disease becomes quiescent, the "root" signs become less troublesome. Rarely do paraplegic symptoms arise from pressure on the cord due to deposits on the neural canal. As the recorded cases show, the paraplegic signs are not permanent, but subside as the nerve root signs diminish. The nerve symptoms are not universally regarded as being due to pressure. The effects of cachexia, slight myelitis, and neuritis have been invoked.

We come now to what may be called the mechanical symptoms. In most cases kyphosis or marked round shoulders is present. Indeed the appearance is very like the kyphosis of adolescence, but

FIG. 253.—Anterior view of patient in Fig. 252.

the rigidity is much more extensive, and often involves the whole spine. The result of this is that the patient's neck slopes forward and the face looks downward, so that in order to look in a horizontal direction the pelvis is tilted backwards, and the knees are flexed. The mechanism of this will be seen by referring to the compensation in Pott's disease (see p. 100). In this way a characteristic gait and attitude arise. In lying supine too, owing to the fact that a bent and rigid spine cannot be adapted to a plane surface, if the lumbar region rests on the couch the head and neck are away from it. If, and it is often the case, the hips are ankylosed, with the thighs partly flexed, the condition is more striking still. The curved spine and the thighs form a segment of a circle. If the patient is placed prone, he rests on his forehead and knees, his body between these points forming the segment of an arch.[1]

A few words must be added about the symptoms of the so-called Bechterew and Strümpell-Marie types.

FIG. 254.—Spondylitis Deformans and Arthritis Deformans in a man, aged 21 years, under the author's care.

In the former it is held that the process starts above and progresses downwards. Kyphosis is always present, with fixation or partial limitation of movement of a part or whole of the vertebral column. The "root" symptoms, that is, the various signs of nerve irritation, are marked, and the general muscular condition is paretic.

[1] See the figures given by Wullstein in Joachimsthal's *Handbuch*, also the figures from Feindel and Froussard given by him ("Un Cas de spondylose rhizomélique,' *Nouvelle Iconographie de la Salpêtrière*, 1898, and Pt. II. p. 1268, *Hdbch. orth. Chir.*).

The large joints of the limbs are not affected, and ætiologically, heredity, trauma, and syphilis are marked. The disappearance of the thoracic respiratory movements is not constant.

In the latter type the disease is said to start lower down and progress upwards, to be associated with *complete* ankylosis of a part or whole of the vertebral column, and the larger joints of the limbs are at the same time affected (hence the name, rhizo = root, melos

FIG. 255.—Posterior view of patient seen in Fig. 254.

= extremity). But, symptoms in the joints of the limbs are sometimes seen in cases otherwise of the Bechterew type. In others kyphosis is absent; and the site of origin and direction of progress are rarely definite, at least clinically.

Diagnosis. — Usually the diagnosis is not difficult. The absence of inflammatory signs, abscess, angular deformity, and the peculiar chronicity, sufficiently differentiate it from caries.

Wullstein's suggestion that some cases of the so-called Bechterew type may have been tabetic spondylitis is valuable. Also the muscular rigidity in others has simulated myositis ossificans.

Other pitfalls are chronic rheumatism, and in one case syringomyelia. When present, perhaps the most significant of all symptoms is the fixation of the ribs.

Treatment.—Various measures have been tried. Cod-liver oil and the iodides have been given, and baths and massage, with the local application of iodine, have been employed.

Forcible redressment has been attempted by Strümpell and

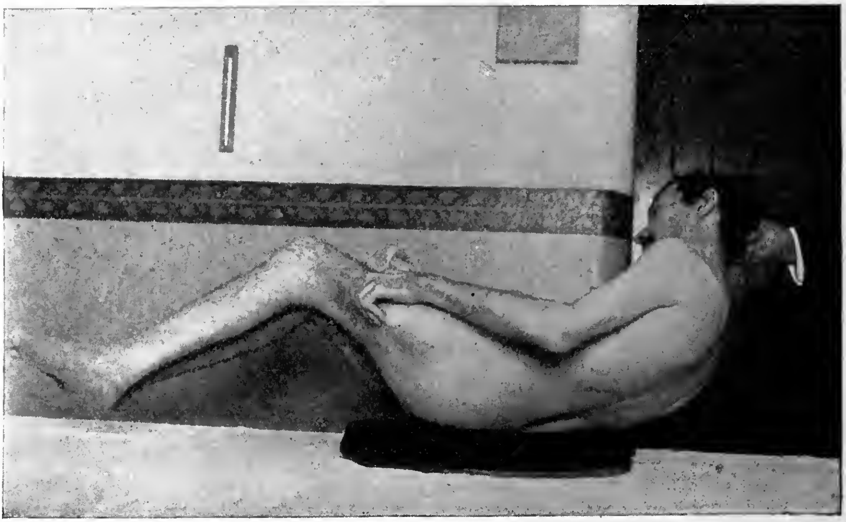

Fig. 256.—Spondylitis Deformans, associated with Ankylosis of nearly all the large joints (Anschütz).

Wullstein. The latter describes the sensation due to the cracking of the ankylosis as "unholy." Lorenz, after a very careful attempt, saw permanent paralysis of the legs and sphincters. Knowing the pathology of the disease we cannot be surprised. A resection of the flexed hip was done by Pierre Marie. In that case the result was bad.

Spinal supports are most useful to arrest deformity and to relieve acute symptoms. They must not, however, obstruct the abdominal respiration.

FIG. 257.

FIG. 258.

FIG. 259.

FIG. 260.

Four figures of a case of Spondylitis Deformans, affecting the cervical and dorsal regions of the spine. The extent of the deformity is seen in the varied attitudes, pictured here (L. Wullstein).

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Gout

Gout, in so far as it affects the bones and joints, requires a brief description. It usually commences in middle life, though some unfortunate people are afflicted as early as the twenty-fifth or thirtieth year, especially when there is a marked hereditary taint.

It begins usually with an acute attack, which subsides into a more or less chronic condition, with occasional lighting up. A common site of the first attack is the metatarso-phalangeal joint of the great toe; and later on, the joints of the hands, the knee, the elbow-joints, and their neighbouring bursæ, are attacked. In an acute attack, the synovial membrane is red and thickened, and some fluid is poured out in and around the joint. The temperature of the body rises, the pain in the affected part is intense, and the tissues over the joints involved are acutely red. As the swelling increases, the pain lessens. Later on, the parts pit on pressure, and the skin cracks and desquamates.

The changes in the joints are as follows :—In a gouty joint the articular cartilages show deposits of urate of soda, at first in its substance; then, the surface of the cartilage is involved, and it becomes roughened, irregular, and eroded. The ligaments and the synovial membrane with their fringe-like processes soon show deposits of urate of soda. Finally, the ends of the bones become enlarged, and bony outgrowths occur at the margins of the articular surfaces.

Extra-articular changes take place, chalky deposits being found in the connective tissues, aponeuroses, and tendon sheaths. On account of the extra and intra-articular changes, and the contraction of the muscles, fasciæ, and ligaments, severe crippling ensues.

The treatment of gout belongs to the province of "Medicine."

SECTION IX

OTHER AFFECTIONS OF THE BONES AND JOINTS

CHAPTER I

OTHER AFFECTIONS OF THE BONES AND JOINTS

Sprains of the Joints of the Limbs and Spine—Other Traumatic Affections of the Spine, Railway Spine—Coccygodynia—Acute Synovitis—Chronic Synovitis of the Shoulder, Elbow, Wrist, Hip, Knee, Ankle-Joint—Snapping-Hip—Trigger-Knee—Loose Bodies in Joints—Internal Derangement of the Knee-Joint—Morrant Baker's Cysts—Recurring Dislocations of the Temporo-Maxillary and Shoulder Joints, of the Patella—Ankylosis—Formation of New Joints (Ne-Arthrosis).

SPRAINS

SPRAINS are the results of twists, wrenches, and sometimes of blows. They may be described as partial and momentary displacements of the articular surfaces, with injury to the joint-structures and the surrounding tissues. The joint is temporarily moved beyond its proper range, and the parts are unduly stretched. In the severer forms, a small piece of bone is sometimes torn away, and the condition is then known as "sprain fracture." This occurs occasionally at the internal malleolus, and about the lower ends of the bones of the forearm. In a sprain of moderate severity the incidence falls upon the synovial membrane and sub-synovial tissues. The capsule may be over-stretched in one direction, or some of its fibres torn, and the surrounding tendons may be stretched, displaced, or ruptured, with the result that a more or less acute teno-synovitis follows.

The pathology of the affection is that incidental to trauma of the joint. Blood is poured into the interior of the cavity and the surrounding tissues. After a few hours, an acute inflammation of a simple character is set up within and around the joint, giving rise to acute synovitis and to teno-synovitis. In three to ten days the inflammatory symptoms subside, leaving the parts weak and painful and swollen, or even œdematous. Matting of the extra-articular structures may occur, and "tender points" are not uncommon, especially on the bones from which ligamentous fibres have been torn away, or along the course of the tendon sheaths. In time, however, in a healthy individual the joint resumes its normal functions, although in gouty and anæmic folk feelings of weakness are present. One of the determining causes of flat feet in gouty people is a sprain of the ankle. When the symptoms persist for a long time the term "chronic sprain" is used.

Symptoms.—At the moment of injury a sharp, sickening pain is felt, which may be accompanied by a tearing sensation of the parts, and the patient is often unable to move the joint. In about half an hour swelling sets in, due to extravasation of blood, and this increase in size is augmented in two or three days by the inflammatory reaction in the joint and periarticular tissues. In superficial joints, ecchymoses appear beneath the skin, which serve to indicate the site of the tissues most damaged, affording later on a guide for treatment. Gradually, swelling and disability subside, and in most cases disappear.

The **prognosis** is favourable, and is of course influenced largely by treatment. **Diagnosis** is a matter of the utmost importance, and the greatest care should be taken to avoid error. In any doubtful case, an X-ray photograph should be taken. It is astonishing how often in so-called sprains a fracture is detected by their use. The vulgar opinion that a sprain is worse than a fracture is nonsense. It is often advanced in the Law Courts by a plaintiff seeking compensation for injury, and when accepted by a jury causes considerable hardship to the defendant in the matter of costs.

Treatment.—All rational treatment of sprains is based upon an appreciation of the events in their order of occurrence. Thus, the moment a sprain occurs, the injured part should be placed at rest, with the objects of preventing any further damage to the tissues and of limiting the effusion of blood. Immediately after a sprain, the part should be bathed in cold water for twenty to thirty minutes, and then firmly bound up with cotton wool and a bandage. It is of no avail merely to wrap the cotton wool round the joint, but it should be so placed as to fill up the hollows and exercise pressure upon them, thus limiting the extent of effusion around and into the joint. The part may be placed on a splint for a day or two; and the patient should rest the injured joint. Twenty-four hours after the sprain, the joint is put either into hot water or in a hot-air oven for twenty to thirty minutes, and then gently massaged for a few minutes. This is repeated day by day. The object is to promote absorption of blood and plasma. In the intervals between the employment of heat and massage, the joint is supported by a pad of cotton wool and bandage, or by cotton wool and adhesive plaster strapping. At the end of a week or ten days hot water is discontinued, although massage is still used, and it is now advisable to stimulate the tissues of the joint by frequent douches of cold water. As the part becomes stronger the supports can be discarded, and then passive movement is usually permitted. Care should be taken that those ligaments which have been stretched or torn are not pulled upon. Thus, supposing that we are dealing with a sprain affecting the internal lateral ligaments of the ankle, passive movements should be those of inversion, and not of eversion. In this way the healing of the ligaments is not interfered with.

This treatment is preferable in every way to that of prolonged fixation of the joint, which frequently results in stiffness and disability.

Chronic Sprain.—Chronic sprain may follow a badly treated acute injury, the symptoms persisting for the following reasons:—Either, the patient assumes an improper attitude to spare the sensitive parts, or, the immobility has been maintained so long that the joint has become fixed in a faulty position. In the latter event atrophy of the muscles and even of the bones may occur, whilst the effused material organises and glues the parts together. Occasionally it happens that "tender points" remain around the joint, especially in nervous people, who will not use it for fear of pain. These patient's descriptions are often highly coloured and exaggerated. It is noticeable that in this class of people circulatory disturbances are present, as indicated by venous congestion and œdema; and the patient firmly resists any attempt to restore the part to its normal position. In rare cases there may be a slight subluxation remaining, as for instance of the astragalus at the ankle, and the foot becomes fixed by secondary changes in the muscles and ligaments. Finally, undetected fracture may exist, or the disability may be due in tuberculous subjects to the onset of that form of arthritis.

Treatment.—Much care must be used in discriminating the cause of the persistency of the symptoms. Presuming that constitutional conditions, such as gout and tubercle, have been eliminated, and an X-ray examination shows that there is no fracture, massage and passive movements may be used in the first place, and any "tender points" either blistered or painted with liniment of iodine, or the joint rubbed with a lotion composed of linimentum belladonnæ, linimentum aconiti, and linimentum chloroformi, in equal parts. If it is evident that the condition will not yield to these measures, and that adhesions have formed, or that the part is persistently and perhaps wilfully held in an abnormal position, forcible manipulation under an anæsthetic is required. Afterwards, it is usually advisable to fix the part in a plaster of Paris bandage, and encourage the patient to use the limb. When he can do so, the bandage should be removed, and in the case of the ankle or knee a light support is applied. Massage and passive manipulations may often be required for a considerable time before the part is properly restored to its functions.

The usual mistakes made about sprains are, that the patient attempts to walk it off at the time of injury; that proper support is not maintained during the period of pain and weakness; that fixation is too prolonged; that massage and passive movement are not used sufficiently early; and, finally, that the patient pays too much attention to the pain and œdema which must necessarily result from using a part which has been injured, and then placed at rest for a little time.

Sprains which are of special interest are those of the knee, ankle, and wrist. Thus, we have seen, after a bicycle accident, complete tearing of the internal lateral ligaments of the knee-joint. The condition is a serious one, and calls for prolonged rest whilst the torn ligaments heal, and it is likely to result in a condition of genu valgum. Such cases require the use of a support to the knee by way of after-treatment. The ankle is particularly liable to sprains, and as a rule good recovery takes place. It is advisable to determine the exact site of injury by noting the points of tenderness, of swelling, and pain on manipulation; and, in after-treatment, care should be taken not to drag upon the injured spots. Early movement is advocated, and the patient should commence to walk as soon as the swelling begins to subside. If the part is well supported, the difficulty in progression rapidly decreases.

Contusions of the Spine

Contusions of the spine and the soft parts of the back merit attention, not so much by reason of the injury itself, but on account of the likelihood of damage to the spinal cord in severe cases. Contusions which appear to be of little importance have been followed by cord symptoms in the course of a few days; and in some instances of severe contusion, where death has followed, the cord has been found completely disorganised by hæmorrhage into its substance. If the cord be not involved, the contusion follows the ordinary course of such an accident elsewhere, except that frequently there are complaints of considerable stiffness in the back extending over a long period. If sensory or motor disorders appear, especially if the action of the bladder or rectum be interfered with, then the case demands additional care.

Sprains and Concussion of the Spine

They vary very widely in their severity. Thus in the mildest degree the muscles and their tendinous attachments are involved, and then there is merely a little stiffness and tenderness over the affected area. In severer cases the ligaments may be torn, and an extradural hæmorrhage may follow, especially if the ligamenta subflava be torn; and many cases of so-called "concussion" of the spinal cord, followed by grave nervous symptoms, are due to a temporary crush of the cord at the time of injury, accompanied by some displacement of the bones, which, immediately after the accident, recoil to their normal position.[1] The symptoms are pain (aggravated by movement), stiffness, often localised tenderness, and discoloration from effusion of blood. The tenderness on pressure is generally found over several vertebræ, and patients complain that they feel "extremely weak in the back." Some affirm that it is impossible to stand up. The prognosis of the case depends largely upon whether the cord and nerve-roots are injured. In cases of slight sprain, the symptoms pass off after a few days. When the injury has been more severe, signs of cord-mischief may make their appearance.

The treatment, both of sprains and contusions, when uncomplicated, is summed up by rest, friction, or rubbing with sedative liniments and massage. When the patient gets about, the support of a bandage or strap is useful to him. If there be evidence of injury to the cord, absolute rest from the first is essential, and every attention must be paid to the condition of the lungs, the bladder, the rectum, and the prevention of bedsores.

The patient should not get up until the symptoms have passed off. It must not be forgotten that a large proportion of sprains of the spine, especially those occurring from railway accidents, are

[1] Thorburn, *Surgery of the Spinal Cord*, p. 12.

followed by symptoms of a neurasthenic or hysterical character, and the condition is known as "traumatic hysteria" or "railway spine," but it would be better called "railway brain," as in many cases it is a functional affection of the higher cerebral centres.

Railway Spine, or Traumatic Neurosis

The surgeon is often consulted in this affection, and a few short remarks will not be out of place here. They follow very closely the articles by the author in the *Encyclopædia Medica.*

For our knowledge of this subject we are mainly indebted to the writings of Erichsen, H. W. Page, and Thorburn.

By railway spine is meant a functional disorder of the nervous system, or some part of it, in which there is no gross lesion of the spinal cord, although the symptoms simulate organic disease. It should be clearly stated that in the so-called "railway spine," the injuries to the soft parts do not differ from injuries to similar structures elsewhere, but they are coloured and are markedly influenced by the fact that they are sustained under exceptional circumstances, such as a railway accident—circumstances which are often extremely horrifying to those concerned. The conditions which are included under the term "railway spine" are by general agreement the following:—(1) A simple sprain of the muscles of the back which may get quite well; but more often it is followed by (2) A general prostration or a condition of neurasthenia. It is to be noted, however, that this neurasthenia may also come on either with or without the history of definite injury. (3) A state known as traumatic hysteria.

Conditions (2) and (3) are functional disorders of the nervous system, and they must not be confused with symptoms due to inflammatory conditions and degeneration of the spinal cord. The terms "railway spine" and "concussion of the spinal cord" are not synonymous, because concussion of the spinal cord is one of the rarest of injuries, and railway collisions do not appear to be in any way specially productive of it. The expression "traumatic neurosis" seems to cover fairly exactly the disturbance of function occurring in these accidents. To go more fully into these points. A simple sprain of the back gives rise to apprehensions on the part of the patient, because his mental balance is somewhat disturbed by the accident, and to the lay mind the symptoms of a sprain of the back are easily confounded with those due to nerve lesions. For instance, after such an injury there will sometimes be tenderness over the transverse processes, or the spinal muscles will be stiff, and the patient feel that he is unable to move freely. When he attempts to stand up, he finds the back is weak and "gives way"; and there are often some hyperæsthetic patches on the skin which, on being touched, give him exquisite pain. If, in addition, he finds that there is some difficulty in micturition, and that the bowels are constipated, his apprehensions are increased. Nevertheless it is noteworthy, that when examined, and when the hyperæsthetic patches are touched, he moves the back freely; wherein, as Mr. Page rightly says, lies a sign of great diagnostic value, for it serves to exclude organic injury, and is a distinct indication as to the line of treatment to be adopted.

If the symptoms of organic nerve-lesions are carefully excluded, and if there is no definite rigidity of the column, the course of treatment is quite clear. The patient should not be allowed to remain in bed. He is to have, in the first place, passive movements, and then use the muscles of the back after time has been allowed for repair of the muscular and ligamentous structures. Very valuable, too, are vibratory massage and electric heat; while the static currents, direct and indirect, rapidly improve the general and local conditions.

It will be readily understood that, owing to the imperfect knowledge of the lay mind as to the relative value of symptoms, and in people of nervous temperament—especially in those who have overworked or indulged to excess—the tendency will be to dwell upon the symptoms until the patient slips into a state of neurasthenia and general prostration. This may even come on without any definite injury, and is then due directly to nerve shock.

To quote Mr. Page again, he remarks upon a very singular fact, namely, that "in those cases where an injury, such as a fracture or crush of a limb, has been sustained, followed by the usual signs of shock, it is not nearly so common to see the evidences of general prostration afterwards, as in those cases where there was no physical injury and the immediate signs of collapse were only slight. The explanation of this lies, in all probability, in the fact that in the former case the collapse is dependent upon the injury sustained; and in the latter the signs of shock are likely to be delayed in their manifestation, being warded off by the excitement of the scene." Thus a patient after a collision may be able to extricate himself, and finding he is uninjured, attends to the wants and hurts of others, and feels nothing until he goes home, when suddenly he collapses. After a day or two he feels better, and attempts to attend to his work, and finds that he cannot do it as well as he used. So that whether there is a sprain of the muscles of the back or not, a man may pass into a general state of hypochondriasis and even of melancholia, with all its attendant symptoms. In effect he becomes the subject of "auto-suggestion," or, as Charcot termed it, "traumatic suggestion," and nurses the belief that he is physically incapacitated. Then, finding that his business is not being properly attended to, and convinced that his nervous system is hopelessly shattered, he drifts slowly but surely into chronic invalidism, both mental and physical.

Traumatic Hysteria.—As an immediate result of the railway accident—even without injury and due entirely to fright—the man has an hysterical attack, or he may be reduced to a condition of semi-unconsciousness, or be dazed; and, he may persuade himself that certain things have happened to him, which onlookers know not to be the case. Either the hysterical attack or the state of unconsciousness is followed immediately, or at a later period, by paresis or paralysis of the hysterical type. Such symptoms are entirely of cerebral origin. In fact, the condition is "railway brain" and not "railway spine."

The signs and symptoms of hysterical paralysis are familiar to all medical observers. It must not be concluded, however, that the patient is malingering because he is thus affected. To him the symptoms are real, and his exact condition is that he cannot "will" to carry out functions, which are only in abeyance.

Since the question of compensation is generally well to the fore, the patient worries himself as to the amount he is legally entitled to. He is apprehensive of the publicity of an action, while the necessary examinations by surgeons concentrate his attention on the condition he feels himself to be in. Therefore it is not to be wondered at that a fair proportion of these patients get well immediately the question of compensation is settled; and the kindest treatment is to induce them to come to as speedy a settlement as possible of their claims. It will be gathered, from what has been said, that it would be very unfair to suppose that, because the symptoms improve after the settlement of the claim, or after a successful action, the patient is a malingerer; for, cases are recorded where, after a temporary improvement, the patients have steadily gone down hill, and death has supervened from exhaustion. Such a one is recorded by Thorburn.[1] At the same time the possibility that an unjust or excessive claim is being made on insufficient grounds should always be borne in mind by the surgical expert, and much acumen and wide experience are needed to detect attempted frauds.

The *treatment* of railway spine may be shortly summed up. Sprains of the back are dealt with on the usual lines for sprains elsewhere, whilst if nerve symptoms supervene, soporific and narcotic drugs are best avoided. Change of scene, fresh air, plenty of good simple food, an ample amount of rest, together with the removal of the worry incidental to the question of compensation, are generally sufficient to bring about a restoration to health.

Spondylitis Traumatica (Traumatic Spondylitis).—Kümmell[2] first described the affection, and believed it to be due to a rarefying osteitis after injury. Reuter's[3] opinion is that the condition is the result of partial fracture and compression of the vertebral bodies, with subsequent static changes. Gillette[4] quotes the case of a fireman, aged thirty-five, of perfect physical development, who sprained his back, whilst lifting a heavy weight. Five months later, paraplegia developed, and associated with it there were slight prominence and rigidity of the lower dorsal region. Death occurred later and, post-mortem, periostitis of the affected vertebræ was found, with caries of both the bodies and arches. No pus, but serous synovial fluid was present.

Another case of Gillette is instructive:—A robust young man, a woodman, sprained his back, and later on there appeared a prominence of the first and second lumbar vertebræ. Caries was diagnosed and death occurred, and it was found that in the bodies of several vertebræ the normal spongy bone was reduced to a dark red pulpy mass, surrounded by a shell of compact bone externally. Numerous nucleated red blood cells and large mono-nuclear cells, undergoing mitotic changes, were seen microscopically.

These cases were evidently not Pott's disease, since the post-mortem appearances were non-tuberculous. T. Halsted Myers[5] also quotes cases which more or less bear out his contention that a class of case exists, where traumatism is followed by many of the same symptoms as in Potts' disease, yet are proved by subsequent history

[1] *Contributions to the Surgery of the Spinal Cord*, p. 223.

[2] *Deutsche med. Woch.*, 1895.

[3] *Zeitschr. f. orth. Chir.* ii. 2, 137. Reuter also gives a full bibliography.

[4] "Traumatic Spondylitis," *Trans. Amer. Orth. Ass.* vol. x., 1897, p. 15.

[5] *Trans. Amer. Orth. Ass.* vol. xi., 1898.

to be non-tuberculous. Painter and Robert Osgood[1] report four cases of injury where kyphosis developed without tuberculosis, in which there were symptoms of pressure upon the cord. The patients, however, entirely recovered in a few months, after treatment by plaster of Paris and poroplastic jackets. These authors have also found fifteen other cases which seem to have been uncomplicated rupture of the spinal ligaments with subsequent development of temporary kyphosis. Chipault[2] speaks of traumatism, followed after an interval by the appearance of lordosis, kyphosis, and scoliosis. Bettman[3] also discusses this question. Reuter[4] says that the clinical course of spondylitis traumatica is typical. After a more or less slight sprain or injury to the back, which causes very little suffering, the patient soon returns to his accustomed work, and only after weeks or months have passed does severe pain call attention to a rounded kyphosis, generally in the dorsal region. Reuter admits that the pathology is unknown; Kümmell calls it rarefying osteitis; von Recklinghausen styles it traumatic osteomalacia. In many cases paraplegia and other nerve symptoms develop. However, we must conclude that many of the cases described are examples of traumatic osteomyelitis; others are osteo-arthritic or instances of von Bechterew's disease, and the remainder are due to fracture-compression. The treatment is absolute rest in the recumbent position, and support and fixation of the spine.

Rupture of the Spinal Ligaments.—Painter and Osgood[5] have drawn attention to rupture of the posterior spinal ligaments from excessive flexion, causing a kyphosis. This deformity is only seen in the erect position, and disappears on recumbency, when the pain is lost. The treatment is rest and support to the spine.

The subject of fracture of the spine is not within the limits of this work.

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[4] *Zeitschr. f. orth. Chir.* Bd. ii. Heft 2, 1903, and *Amer. Jour. Orth. Surg.*, August 1904.
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COCCYGODYNIA

Coccydynia, or coccygodynia, is a painful condition in and about the coccyx. It is more common in females than males.

In the severe cases there is a history of a fall or a blow, such as a kick. In other cases it is brought about by horse-riding, and in yet others it follows prolonged or difficult labour. Sometimes no cause is assigned, and no lesion of the coccyx is found; but frequently the coccyx is dislocated either forward, backward, or laterally. In traumatic cases we have occasionally found a small bony nodule situated at the tip or on one side of the bone, and pressure over the nodule causes great pain. Occasionally the tip only of the bone is tilted backward. Such cases we have found to be more painful than other types.

Symptoms.—Pain sometimes of a lancinating, at other times of a dull nature is present. It is often increased on walking or defæcation, and the patient is unable to ride in a jolting vehicle. If the bone is pressed with the finger *per rectum*, it is very tender and is often fixed. The pain is referred to the fifth sacral and coccygeal nerves. The position of the bone or of its tip is ascertained by external and by rectal examination. Many of the sufferers are eminently neurotic.

Treatment.—Some cases yield to local applications of oleate of morphia; and it is not advisable to use counter-irritants on account of the nearness of the anus and the probability of setting up eczema in the gluteal cleft. The patient is also advised to keep the bowels well open and to sit upon an air-cushion, or to lie recumbent on the side for a week or two. Occasionally the pain disappears. If it should not, then removal of the bone is recommended. It is a simple operation, and the knife should be kept close to the bone so as to avoid injuring the fifth sacral and coccygeal nerves. After separating the fascia from the tip of the bone, the anus becomes somewhat patulous owing to the origin of the external sphincter losing its fixed point. If care is taken to pass a deep suture from the periosteum of the sacrum through the tendon of the external sphincter, and tie closely, the anus soon resumes its normal appearance. After the operation, the legs are tied together, and the patient is directed to lie upon the side. A purgative is given on the third day, and the bowels are kept loose by salines for several days. Healing is complete by the tenth to the fourteenth day. No recurrence of the trouble occurs, except in very neurotic women.

Acute Synovitis

We have already described (Vol. II. p. 366) that severe type of acute synovitis, associated with infectious diseases of the joints. It therefore remains for us to allude to that form which is associated with injury, loose bodies in the joints, and displacement of cartilages.

The symptoms are increased heat of the part, limited movement, discomfort, and swelling. The capsule frequently becomes distended with fluid, the outlines of the joint are lost, and the patient holds the joint in that position in which the strain upon the ligaments is least. The symptoms are best marked in the case of the knee-joint.

From a therapeutic point of view it is essential to ascertain what is the exciting cause, and the nature of the treatment must be dependent upon the diagnosis.

If the case be a traumatic one the limb should be elevated, placed at rest on a splint, and in the early stage an ice-bag is applied. So soon as the acute stage has passed away, and if the fluid is slow in becoming absorbed, a proper degree of pressure is applied. That is to say, the sites of the normal hollows around the joint should be well fitted with cotton-wool pads, and over them adhesive plaster strapping fixed. Until all fluid has disappeared, no active movements can be permitted. If the absorption of fluid is slow, counter-irritants, *e.g.* linimentum iodi, or absorbents, such as oleate of mercury (10 per cent), may be used. When absorption of fluid is taking place steadily, the process may be expedited by douching with hot and cold water and gentle massage.

It is advisable in all cases, when the patient begins to use the part again, that the movements be limited either by strapping or by a simple form of apparatus, and the neighbouring muscles be massaged.

Frequent attacks of acute synovitis result in permanent relaxation of the ligaments and loss of stability of the articulation.

Chronic Synovitis

Synonyms—Dropsy of the Joint; Hydro-arthrosis.

Causation.—(1) As a sequel of acute synovitis; (2) As a complication of loose bodies and internal derangements of the joint; (3) Arthritis deformans; (4) Rheumatism and gout; (5) Hæmophilia; (6) Infection of the joint by septic disease; (7) Repeated strains, such as occur in genu valgum and slipping patella; (8) Excessive body-weight carried by the part.

Intermittent Synovitis.—This affection is sometimes observed in young girls, and is associated with menstrual irregularities. It is a non-inflammatory serous effusion, occurring at more or less regular intervals, lasting for a few days, disappearing and then returning, and often resulting in laxity of the ligaments. Synovitis of this or the chronic type, frequently repeated in one joint, which fails to yield to treatment, should give rise to the suspicion of tuberculosis.

Pathology.—In chronic serous synovitis we find the synovial membrane vascular and thickened, and the villi hypertrophied. The subsynovial tissue also partakes of these changes. As time progresses, the ligaments and capsules become lax, the muscles of the limb slightly wasted, and the part is rendered insecure.

Treatment.—The cause must be ascertained and treated. If effusion is slow in disappearing, massage, manual or vibratory, electric light baths, or Bier's active and passive hyperæmia, will hasten the absorption of the fluid and lessen the thickening of the synovial membrane.

Intermittent Hydrarthrosis

Of the ætiology of this affection very little is known. It does not appear to be dependent upon any clearly defined general or local condition. Schlesinger[1] has noted the association of acute circumscribed œdema with intermittent hydrathrosis, and both these affections are periodic. Garrod[2] refers to the coincidence of some articular lesions with transient cutaneous erythemata such as erythema nodosum.

[1] *Mittheil. aus den Grenzgeb. der Med. und der Chir.*, 1899, xv.
[2] *Quarterly Journal of Med. Sci.*, Jan. 1910.

The possibility of the effusion being due to malaria is discussed by Howard Marsh and Gordon Watson,[1] only to be dismissed by reason of insufficient evidence; and a review of the recorded facts clearly shows that we know nothing of the causation.

It occurs more often in females than in males, and has been met with from the 8th to the 50th year, but is most common in early adult life. The periodicity varies, although each case has its own cycle, which is remarkably regular. Sometimes it recurs at a definite hour daily, or the effusion may appear about once in any time up to 30 days. From the 9th to the 15th days is the usual duration of the period.

All the large joints have been involved, but the knee is the most usually affected; and when only one joint shows effusion, it has been the knee.

Symptoms.—The onset of the effusion is often preceded by neuralgic pain, and when the fluid is being poured out there is frequently severe arthralgia. Sometimes, however, arthralgia and effusion alternate. The joint affected swells rapidly and is tender. In some patients considerable wasting of the muscles of the limbs occurs.

Treatment.—So far the only drugs which have proved to be at all efficacious are quinine and arsenic. Naturally, during the attacks the patient keeps the painful joint immobile, although prolonged rest seems to have no effect whatever in preventing the recurrence of the attacks.

Chronic Synovitis of the Shoulder-Joint

Chronic synovitis of the shoulder-joint is generally the result of some injury, or is a symptom of commencing tuberculous infiltration of the part.

If, in a young person, it is found that movements of the joint under an anæsthetic are not successful in relieving the stiffness, or result in increasing limitation of movement, then the condition is probably tuberculous.

In the simple form, pain, limitation of movement, and the globular appearance of the shoulder, with atrophy of the neighbouring muscles, are the usual signs.

[1] *Diseases of the Joints and Spine*, 3rd ed., 1910, p. 19.

The treatment is conducted on ordinary rational lines as for peri-arthritis of the shoulder or subdeltoid bursitis.

Chronic Synovitis of the Elbow-Joint

There is nothing special to remark about it, except its relationship to tuberculosis. In the "tennis elbow" a chronic synovitis is often present, due to strain of that portion of the capsule of the joint named the internal lateral ligament, and of the common tendon of the flexor and pronator muscles. In some instances the writer has seen it associated with tenderness of the pronator radii teres muscle, and in one case there was tenderness and swelling at the insertion of that muscle into the radius, which was probably due to an inflammation of the small bursa situated on that bone. Rest to the part with counter-irritants, and massage later, will eventually effect a cure, although some of the cases are obstinate.

Chronic Synovitis of the Wrist

This is similar to that occurring in other joints. Whether acute or chronic it is very common, particularly in those who use their hands excessively, such as musicians, and especially players on the piano.

In these cases it is often difficult to carry out effective treatment, and the trouble is likely to be recurrent because they use their hands too soon. The treatment is the same as for chronic synovitis elsewhere.

Synovitis of the Hip

When this occurs in children the suspicion of oncoming tuberculous disease is frequently entertained. The nature of the affection can be verified only by careful inquiry into the history and antecedents, by noting the way in which the symptoms yield to treatment, by prolonged clinical observation, and by X-ray examination.

In children, synovitis arises from injury, rheumatism, or a mild type of septic arthritis, such as occurs in tonsillitis, diphtheria, and other throat affections, or in the attenuated forms of osteomyelitis and epiphysitis.

As a rule the non-tuberculous type of synovitis of the hip does not last more than fourteen to twenty-one days, and it is associated with limitation of movement, lameness, and temporary atrophy of muscles.

In adults, the causation is referable to rheumatism, gonorrhœa, syphilis, and arthritis deformans.

Treatment.—In children, the treatment is precisely similar to that practised in the early stage of hip-joint disease, and it is imperative at this age to watch the patient carefully to see if the recovery is permanent.

In adults, rest, weight-extension, and counter-irritants, followed by massage, are indicated, and the patient should take care not to use the joint too soon.

Chronic Synovitis of the Knee

Among the causes which give rise to chronic serous synovitis in this joint, the most prominent is the irritation produced by loose bodies in the joint, hypertrophied synovial fringes, lipoma arborescens, displaced semilunar cartilages, and the atrophic form of arthritis deformans, or as it is usually called, "rheumatoid arthritis." Persistent strains of the knee, such as occur in flat foot and genu valgum, are also potential factors in producing a long-continued effusion; and, at all times the possibility of septic arthritis of a mild type must not be forgotten.

It is in this joint that the effect of effusion, so far as the function of the limb is concerned, is the most marked, and a vicious circle is described. Some cause, such as a loose body or displaced cartilage, causes synovitis and effusion, with laxity of the ligaments, which allows too free play between the joint surfaces; with the result that the loose body again gets between them, or the semilunar cartilage is again displaced; then another attack of synovitis ensues, and the ligaments become still weaker.

It is therefore an essential element of palliative treatment in these cases to steady or stay the joint, and to prevent lateral movement especially.

Hypertrophy of the Synovial Villi.—As a result of chronic synovitis the subsynovial tissue becomes overgrown, and the fringes present numerous folds and polypoidal or pedunculated masses, vascular and highly sensitive. At the knee they can often be felt on either side of the patella. When they become much enlarged, and the pedicles are elongated, they may break away from their attachments, and form one variety of loose body. A joint, in which an enlargement of the synovial fringes exists, is never free from discomfort. Dull pain is constantly present, and at times it becomes more or less acute. The joint itself is tender to the touch, and effusion can be frequently detected in it, whilst its movements are often limited.

Treatment.—These cases are often particularly obstinate, and when they occur in neurotic women are the source of considerable embarrassment to the surgeon, for it is difficult to say how much of the pain is due to the joint condition, and how much to the general sensitiveness. The indications are quite clear. The part should be

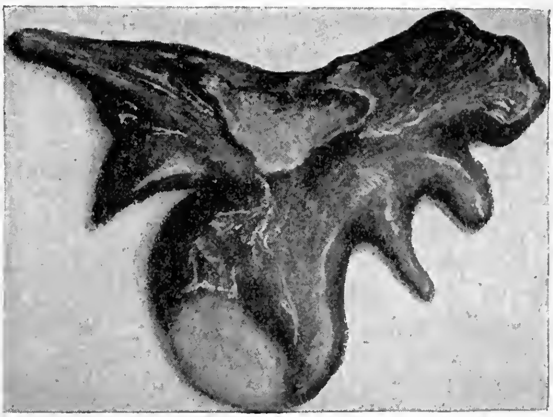


FIG. 261.—Lipoma Arborescens, from a knee-joint (C. F. Painter).

placed at rest, and a mild degree of counter-irritation is often useful, followed by compression by cotton-wool and strapping the joint. As the symptoms subside, douches and massage should be used, succeeded by carefully regulated movements.

When the joint does not yield to this treatment, and the patient's usefulness in life is limited by the affection, the joint ought to be opened—preferably by an anterior semilunar incision dividing the ligamentum patellæ—and the polypoidal growths are cut away. The synovial membrane is then carefully united by sutures, and the parts of the ligamentum patellæ stitched together. It is to be deplored that in this country this practice is not more often followed. We have had great success with it and excellent movement has followed.

After the operation the joint is kept at rest for two or three weeks, and then passive movements are commenced.

Lipoma Arborescens.—As the term implies, this is a growth of fatty origin, and it is most frequently seen in the knee. Such growths vary much in size, and have been described as being as large as a hen's egg. They are of a regular, more or less rounded shape, or irregular (Fig. 261).

According to Painter and Erving[1] they arise in one of three ways: either as a hernia of the subsynovial fatty tissues into the joint; or, they are due to overgrowth of the fatty tissue beneath the synovial membrane, or to fatty hypertrophy of the synovial villi.

When they project into the joint they give rise to exactly the same kind of symptoms as the hypertrophied synovial villi, and indeed they are often indistinguishable clinically.

The best treatment, when they become a nuisance to the patient, is to explore the joint and remove them.

Chronic Synovitis of the Ankle-Joint

This may follow as the result of acute synovitis, or be due to a strain on the part in walking, such as is caused by a contracted tendo Achillis or a flat foot. Some cases of chronic synovitis here are tuberculous in origin, and care should be taken in discriminating the cause.

The symptoms are pain and discomfort in walking, often followed by heat, but without redness, and the natural hollows behind the malleoli are seen to be filled up. The movement which is lessened is dorsiflexion.

The treatment consists of removal of the cause, and rest followed by massage and, if need be, support. Considerable difficulty often arises in walking, when the tendon sheaths in the neighbourhood of the ankle are inflamed and give rise to teno-synovitis. The most common situation is around the tendo Achillis, but every sheath has been found to be affected in this way; and the writer has seen chronic infiltration of the sheath of the tibialis anticus, extending from the middle of the ankle-joint to the insertion of the tendon.

In the acute form of teno-synovitis, pain and tenderness are felt in the course of the tendon, and the part is swollen and often warm to the touch. When the ankle is moved, the characteristic silky

[1] *Boston Med. and Surg. Jour.*, March 19, 1903 (with literature). And Stieda, *Beiträge zur klin. Chir.*, 1896, xvi. 285. Also Roland O. Meisenbach, *Buffalo Med. Jour.*, February 1908.

crepitus is felt, and frequently a hyperæsthetic spot may be localised. In this type, rest to the part is necessary, and counter-irritants are applied, followed by gentle movements and massage. If the trouble does not then subside, the application of a plaster of Paris bandage for two or three weeks is called for.

In the less severe cases there is often a gouty or rheumatic element, and prolonged rest is undesirable. The patient should be encouraged to submit to massage and passive movements early, and to walk about with strapping applied over pads of cotton-wool, so as to compress the affected sheaths.

Snapping-Hip

Snapping-hip is seen both in infancy and adult life. In infancy it is said to occur when the thighs are flexed and adducted. In adult life it is associated with arthritis, or with effusion into the bursa between the gluteus maximus and the femur. According to Thomson and Miles [1] the condition is due to a bundle of fibres derived from the anterior margin of the gluteus maximus, or a thickened band of fascia lata, slipping backward and forward over the trochanter; and a cord-like band, derived from these structures, appears in certain positions. This band is said to give rise to the snapping sound.

Trigger-Knee

Synonyms—*Genou à ressort, Schnellendes Knie.*

Trigger-knee is a curious condition in which, when the knee is gradually extended to about 160°, the remainder of the movement is accompanied by a snap and a forcible jerk, associated with outward rotation of the tibia. In some cases the trigger movement is observable in acute flexion. It appears to be accompanied by looseness of the ligaments, particularly of those attaching the external semilunar fibro-cartilage to the head of the tibia. It is generally stated that there is some alteration of the rhythm of the movement of the external semilunar cartilage, and that in certain positions of the joint it is caught between the surfaces, then suddenly freed, and produces the jerk. Other causes are given.[2] In one case there was

[1] *Manual of Surgery*, 3rd ed. vol. i. p. 789.
[2] R. Jones, *Clin. Jour.*, May 9, 1906.

a nodule the size of a pea growing from the anterior end of the external semilunar cartilage: and in another case, where the anterior portion of the cartilage was thinned and cord-like, it ended in a thickened extremity.

In most cases the prognosis is good, and the condition does not call for operation; but in adults, on account of the local irritation to which the condition gives rise, it is sometimes advisable to explore the joint.

Loose Bodies in the Joints

They have been found in nearly all the large joints, and occasionally in the smaller ones; and they are most frequently met with in the knee-joint They may be classified as: I. Fibrinous; and II. Those composed of organised connective tissue.

I. **Fibrinous Loose Bodies** (Corpora Oryzoidea).

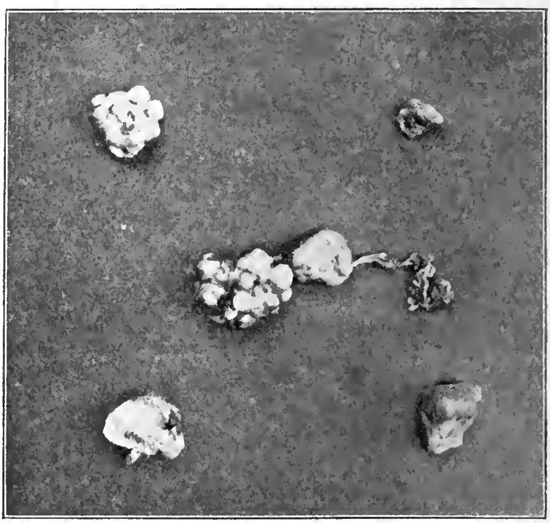


Fig. 262.—Loose bodies from the elbow-joint. This photograph was kindly presented to the author by his colleague, Mr. Walter G. Spencer.

(*a*) Some of the bodies are homogeneous or laminated masses of fibrin, often solitary, but occasionally they are present in large numbers. In appearance they resemble rice-grains or melon-seeds, and they originate from the synovial membrane. Precisely similar bodies are found in tendon sheaths and in bursæ. Chronic effusion

PLATE XXIII.

Skiagram of the Elbow-joint, from which the loose bodies, pictured in Fig. 262, were taken (W. G. Spencer).

To face page 500.

is always present. They are not uncommon in tuberculous synovitis and bursitis, and in arthritis deformans, and it is believed that they arise from the coagulation of fibrin elements in the synovia. As a rule, they do not give rise to the characteristic symptoms of loose bodies in the joints, yet they contribute largely to the crepitating sensation on movement.

(*b*) Another form of loose body is the fibrin which results from an exudation of blood. When this occurs in one of the fringes of the synovial membrane, it may cause symptoms very much like those of a loose body; but, it is not definitely proved that a free exudation into the joint gives rise primarily to a loose body.

II. **Bodies composed of Organised Connective Tissue.**—They are either fatty, fibrous, cartilaginous, bony, or combinations of these tissues. They are seen under two conditions: (*a*) In association with some general disease of the joint; (*b*) in joints which are otherwise healthy.

Under the heading (*a*) are included arborescent lipomata, hypertrophied synovial fringes, detached osteophytes in arthritis deformans and Charcot's disease, detached marginal enchondromata as in rheumatoid arthritis. Under the heading (*b*), "Loose bodies in joints which are otherwise healthy," should be placed encapsuled foreign bodies, bullets and needles, portions of cartilage or bone chipped off by traumatism. Considerable doubt has been thrown upon the existence of the last mentioned, yet there is abundant evidence to prove it.

When the bodies are derived from hypertrophied synovial villi, the connective tissue gives rise to fibrous tissue, cartilage, and bone, in different proportions and combinations. The number of the bodies varies from the solitary large, flat, smooth, movable object to some hundreds, and Bradford and Lovett[1] mention a case where four hundred were removed from one knee-joint. At first those arising in connection with disease of the joint are pedunculated and have a limited range of movement. The pedicles then become stretched, and the bodies wander about until finally they become detached. The small loose bodies are either like melon-seeds or rice-grains, while the larger are disc-shaped, ovoid, or spherical.

When they are removed they are white or yellow, and vary in consistency from softness to bony hardness, and indeed exhibit all grades of density.

Symptoms.—The characteristic point is the sudden onset of

[1] *Orthopedic Surgery*, 3rd ed. p. 233.

severe agonising pain in the joint whilst in the act of stooping or kneeling, or without any well-defined cause; and this pain is succeeded by temporary fixation in the flexed position. The onset is so sudden and the pain is so great that the patient often falls to the ground or faints. Either by movement or manipulation the loose body is dislodged from between the articular surfaces, and the patient is able to extend the joint; but, at other times, the joint remains fixed and more or less flexed, and any attempt to straighten it produces a recurrence of the agonising pain. In the latter event, a more or less severe serous synovitis sets in and persists for some days. The nature of the case is often cleared up by the patient or surgeon feeling a movable body, which can be slipped from place to place.

Sometimes it happens that frequent examinations are necessary before the diagnosis can be determined. The differential diagnosis between the various causes of derangement of the knee-joint will be given later. In the knee-joint, the loose bodies can be detected in the supra-patellar synovial pouches, or in the sac of synovial membrane on either side of the ligamentum patellæ. They slip about the joint in a most remarkable way, and can seldom be found at the time when most needed—so much so that on many occasions an operation has been postponed for this reason.

It seems that after repeated attacks the pain is not so great and the synovial membrane is less sensitive, so that the resulting discomfort and the amount of effusion are less.

Treatment.—When a loose body gives rise to little or no trouble, and can be retained in one position by a knee-cap or a knee-support, operative treatment may be postponed, unless the patient is going out of reach of skilled surgical care. Again, where the number of foreign bodies is multiple, and their presence is associated with arthritis deformans or osteo-arthritis, and the integrity of the joint is so much impaired by the disease, little or no gain can accrue from their removal. If, however, the loose body is a solitary one, or if two or three of fair size can be detected, and if the patient is a healthy adult, operation is called for.

In every case the most rigid aseptic precautions must be observed, and before any incision is made the loose cartilage should be found and fixed by a needle passed through the skin so as to steady it. It is not sufficient to grasp it with the fingers, as it will probably slip away in making the incision. As a definite rule of procedure, no operation for a loose body in the knee-joint should be undertaken unless it is first found and fixed. All searching of the joint with the fingers is strongly to be deprecated.

In some cases, when the patient is placed upon the table, and before the anæsthetic is commenced, the loose body may be made to appear by putting the joint through its paces. The most favourable positions for removal are the supra-patellar pouches; and the mass can sometimes be coaxed there, when it may be cut down upon and slipped out through an aperture in the synovial membrane. The possibility of more than one being present should not be forgotten.

Dislocation of the Semilunar Cartilages and Internal Derangement of the Knee-Joint [1]

Either semilunar cartilage may be displaced, the internal much more frequently than the external, the proportion being 10 or 12 to 1, the disparity being due to anatomical reasons. The causation of the trouble is a twisting or wrench when the knee-joint is in flexion, or to be more precise, a lateral strain on the partially flexed joint.

Before entering into the clinical details we must briefly refer to certain anatomical points. The knee is not a true hinge joint, for rotation of the tibia on the femur takes place on flexion and extension. Normally there is no lateral movement in the joint, this being prevented during slight flexion by the strong lateral ligaments, and in acute flexion by the crucials. It therefore follows that if the lateral ligaments are injured or stretched, lateral movement will cause separation of the tuberosities of the tibia from the condyles of the femur. The semilunar cartilages are attached by their outer margins to the capsule of the joint. The external cartilage is more nearly circular than the internal, and its extremities and its internal attachments lie between those of the internal, and it is more movable. The external edge of the external cartilage is not attached to the external lateral ligament, whereas the internal cartilage has a very firm attachment to the

[1] Cf. Hey, *Practical Observations in Surgery*, 1803; Tenney, *Annals of Surgery*, July 1904 (with bibliography); H. W. Allingham, *Internal Derangements of the Knee-Joint*, London; Robert Jones, "Certain Derangements of the Knee-Joint," *Clin. Jour.*, May 9, 1906; A. E. Barker and E. G. L. Goffé, *Ency. Med.* vol. vi. p. 127; Bradford and Lovett, *Orthopedic Surgery*, 3rd ed, p. 236; Robert Jones, *Ann. Surg.* vol. l. 1909, p. 974, a most valuable and instructive article.

internal ligament. The internal cartilage is of an ovoid shape, less movable than the external, is more closely adherent to the capsule, and, further, blends with the strong internal lateral ligament. Therefore, if any strain is thrown upon the internal lateral ligament, the internal cartilage may be displaced. Inasmuch as the internal lateral ligament is relaxed during flexion, and, whilst in this position, if it is subjected to strain, displacement of the internal cartilage may take place. The most usual position is when the knee is flexed, the foot abducted, and the femur rotated inwards, precisely the position of the left leg during the "tee-shot" in golf. Both semilunars are connected with the tibia by ligamentous

FIG. 263.—Semilunar Cartilages of right knee, showing the effects of long continued friction (Tenney).

fibres of a quarter of an inch or so in length. Normally, the internal semilunar cartilage follows the femur closely in its rotatory movement inwards during flexion, but not beyond a certain point, provided that the attachments of the cartilage to the tibia are not stretched or torn. Another point, we have to notice, is that the semilunars are covered by synovial membrane on their upper and lower surfaces, and this accounts for some of the effusion which takes place in the knee-joint when the cartilages are displaced. There is also a band of fibrous tissue passing from the circumference of the internal cartilage into the internal lateral ligament, which ensures that the cartilage shall follow the femur in rotation of the joint.

It is clear, therefore, that the factors essential to production of displacement of the internal cartilage are, flexion of the knee, rotation of the femur inwards, and a strain put upon the leg in such a way that the line of force passes through the inner side of the knee-joint. This always happens when the foot is abducted, and it is just in this position that exceptional strain falls upon the internal lateral ligament. We have seen how closely it and the internal cartilage are connected anatomically, and we can therefore understand their pathological relationship. Displacements of the semilunar cartilages are mainly towards the centre of the joint; but if, as sometimes happens, the anterior end of the internal cartilage is displaced forwards and outwards, its middle and posterior part rotates in a converse direction; and it is this latter position which gives rise to the symptoms of locking of the joint.

The amount of force required varies very much. In some cases the patient catches the toe in the bed-clothes. In others it occurs during dancing. Some people first slip their cartilages at golf, and in young men it is a very common occurrence at football, due to a blow or fall on the knee.

Symptoms.—Immediately following upon the injury the patient experiences acute pain, and finds himself unable to extend the joint fully. Very shortly afterwards an acute effusion of the knee sets in, and is some days in subsiding. During this time the patient may or may not be able, without surgical assistance, to regain extension of the joint; more often not, as some slight flexion remains. This is an important point, which will be referred to later. The injury, having once occurred, is likely, unless efficiently treated, to be recurrent, and occurs quite suddenly and unexpectedly, the patient falling to the ground. At each successive recurrence the capsule is distended with fluid, and the ligaments become more and more relaxed; this allows great lateral movement of the joint, and is an important factor in the displacement. It is true that the successive synovitic attacks are not all so severe as the first, but the patient is often entirely incapacitated by their frequency. In some cases, but by no means in all, some prominence of the semilunars may be felt.

We must recognise that the lesion consists not only of displacement of cartilage, but of tearing, twisting, buckling, or entire derangement, so that it becomes a loose body in the joint. Tenney[1] has tabulated the conditions of the cartilages found in 128 operations, and his table is appended :—

[1] *Annals of Surgery*, July 1904.

	Internal.	External.
Torn from or near the anterior attachment	23	3
Transverse tear at or near the lateral ligament	38	...
Longitudinal split (incomplete)	16	1
Longitudinal split (complete)	8	...
Turned into intercondyloid notch	3	1
Loose	23	3
Cystic	1	1
Ossified	...	1
Doubtful	1	5
	113	15

Robert Jones[1] tabulates 26 cases. "Thirteen were torn from their anterior attachments, four were longitudinally split, in two the posterior horns were displaced, in two the attachments to the tibia were much stretched, in two the middle parts of the cartilages were pushed centrally into the joint, and in three the anterior portions were thickened and nodulated."

In another place[2] Mr. Jones states that "of 117 cases operated upon by him for injury to the cartilage in which a lesion of the disc was found, 53 were torn from their anterior attachment, 16 were split longitudinally, 8 were attached by the cornua and torn from the capsule, 7 were displacements of the posterior horns, 12 were fractured transversely opposite the internal lateral ligament, 8 were loosely bound circumferentially with no other appreciable abnormality, 8 had undergone changes in the loose anterior extremity of the semilunar and of a nodular type, some being as lumpy and large as a pea; 3 cases exhibited no trace of the cartilage, 2 cases showed the anterior part doubled and adherent to the posterior part. In the remaining cases it was difficult to classify the injuries; some cartilages were so friable as to tear when grasped with the forceps, and others presented fringed edges."

When the displacement is recurrent the edges of the cartilage may become thin and frayed. It is sometimes difficult to decide which cartilage is at fault, although assistance may occasionally be obtained by noting where the most tender spot about the head of the tibia is situated. Yet, it is stated that all the symptoms may point to displacement of the inner cartilage, and on examination the external cartilage is found to be the one affected. The difference in the degree of severity of the symptoms is accounted for by the nature of the injury which the cartilage has sustained. In those

[1] *Clin. Jour.*, May 9, 1906.
[2] *Annals of Surgery*, vol. l. p. 975.

cases where the attachments are merely stretched, neither the pain, the locking, nor the effusion is so great as when they are torn across or buckled.

The *differential diagnosis* between the various forms of affections of the knee causing symptoms, sudden in onset, is difficult. Displacement of the internal cartilage is characterised by the history of violence, followed immediately by pronounced locking of the joint, together with tenderness at the inner side of the patella, and the appearance of abnormal lateral movement of the joint. Displacement of the external cartilage produces similar symptoms on the outer side of the joint. In the case of loose bodies, locking of the knee occurs, but it is short-lived, and often disappears spontaneously. Further, the patient can frequently demonstrate the cause of his trouble. Hypertrophy of the synovial fringes causes symptoms somewhat like those of displacement of the semilunar cartilages, but the pain is always situated over the particular portion of membrane affected, and tenderness is not felt over or near the internal lateral ligament. The hypertrophied mass, too, can often be felt. In lipoma the symptoms are by no means severe as a rule; there is usually a chronic and somewhat tender swelling on either side of the ligamentum patellæ, and effusion is absent. In rupture of the internal lateral ligament, if it occur below the attachment to it of the internal cartilage, no displacement of the latter will follow; but if above, the cartilage may be displaced towards the centre of the joint. In either event, when the knee is extended, a large amount of abnormal lateral movement is present; and in one case we saw, due to a severe fall off a bicycle, the foot could be displaced outwards three inches, with the knee fully extended. Here the tenderness over the ligament was excessive. When the crucial ligaments are ruptured, the tibia can be made to move forwards and backwards on the femur, and if the knee is flexed lateral movements are exceedingly free.

Treatment of Displacement of the Cartilages.[1]—At a first

[1] In this connection a most useful lecture by Mr. D'Arcy Power (*Brit. Med. Jour.*, Jan. 14, 1911, p. 61), entitled "The Results of the Surgical Treatment of Displaced Semilunar Cartilages of the Knee," should be read. He gives statistics of the frequency with which the knee-joint has been opened at St. Bartholomew's Hospital, for painful locking of the joint after an injury, and describes the morbid anatomy of the affection and the differential diagnosis, and most important, the results of operation: "of 89 patients, 73 had experienced no return of the symptoms for which the operation was performed, 16 stated there had been a recurrence." Also cf. "A Clinical Lecture on some of the Common Injuries of the Knee-Joint and their Consequences," by W. Arbuthnot Lane, *Brit. Med. Jour.*, March 11, 1911, p. 537.

attack the proper thing to do is to manipulate the joint, so that the cartilage may be replaced. For this purpose an anæsthetic may be necessary. In any case the surgeon should not rest content until the patient can himself extend the joint voluntarily and fully. Any result short of this is insufficient. Bearing in mind the anatomical points which have been discussed, it is found that the manœuvres which must be carried out to replace satisfactorily the dislocated cartilage are acute flexion, lateral deviation and rotation inwards of the leg, followed by *full* extension. The joint is acutely flexed because the greatest amount of internal rotation can be obtained in this position. It is laterally deviated, so as to free the cartilage from the grip of the bones. And, finally, it is extended because it is found that in making this last movement the cartilage slips into place.

The effusion is treated by the remedies usual for acute serous synovitis, and the limb is kept in full extension on a support which permits no lateral movement whatsoever. The time required for subsidence of the effusion and for re-fixing the cartilage varies considerably. It may be two to six weeks or more; but, so long as the tenderness remains on pressure over the site of the cartilage, or over the internal lateral ligament, the patient should not be allowed to walk. It is only by thorough treatment in this way that a satisfactory result can be obtained after a first injury, and this is all-important.

When the time has arrived for the patient to get about, he is fitted with an apparatus which prevents any lateral movement whatsoever of the joint. There are many forms, but most of them are on this principle: a ring above and below the knee is connected by two vertical steel rods hinged opposite the knee-joint, and a pad is made to press upon the anterior portion of the displaced cartilage. When this is pushed backwards, the middle portion of the cartilage is forced circumferentially. Where considerable laxity of the ligaments remains, the instrument must reach from the middle of the thigh to the middle of the calf; and if the patient still feels his knee insecure, it is advisable to carry the apparatus from the sole of the boot to the upper third of the thigh.

It cannot be repeated too often that the chief factor in the production of this displacement is undue laxity of the ligaments, resulting in lateral movement. Inasmuch as lateral movement of the tibia outwards is the most prolific cause of displacement of the internal semilunar cartilage, it is advisable to wedge up the inner edge of the sole and heel of the boot, and it is necessary in most cases to limit the angle of flexion of the knee. We are accustomed to allow at first 30°, then 60°, and then 90° of flexion. The patient should always be taught to walk with the feet parallel, and run with the toes turned in. In all cases where an apparatus is used, the muscles of the limb should be massaged, so as to brace the joint up, and prevent wasting of the limb, and the loss of the proper fit of the apparatus.

With careful treatment along these lines, not only patients with primary, but some with recurrent displacements, can be rendered comfortable and secure.

A. **Operation, Indications against:**

1. No case of primary displacement is suitable for operation.
2. Nor, as a rule, are those cases where the patient is content to wear an apparatus for a lengthened period.

B. **Operation is called for:**

1. Where the patient is unable to give the necessary time, and has not the means to afford the apparatus required for mechanical treatment.
2. Where the patient is unable to obtain his livelihood, shackled by a splint.
3. In the case of those who go up ladders or work on scaffolds, where a sudden and unexpected fall may be fatal.
4. When a support has been faithfully tried, and has failed.

In every case of operation it should be explained to the patient what are the risks of the operation, and what may be the consequences of any failure in technique. There is in the writer's opinion scarcely any other operation in surgery which requires such exceeding care and is so fruitful of anxiety. When a disaster does occur, it is overwhelming. Unfortunately laymen have an idea that the removal of a displaced cartilage from the knee is a simple and safe operation, but some surgeons know it to be otherwise by sad experience.

Details of the Operation.—The chief point is the most minute attention to aseptic details. In our opinion the usual cause of infection is the patient's skin.[1] It is therefore essential to cleanse

[1] The possibility of disaster arising from an infective focus elsewhere in the body must not be overlooked. The account of the following case, which was under my care, will illustrate this. Ten years ago I operated upon a man, aged forty-two years, for fractured patella, using wire to join the fragments together, and leaving the end of the

this thoroughly, and time is occupied in doing so. The patient is put to bed, and the skin over the knee and the thigh and leg are well washed with soap and water, succeeded by ether, then by absolute alcohol, and finally a compress of 1 in 1000 biniodide of mercury solution is put on for twenty-four hours. By this time a good deal of hardened skin over the knee-cap will be found to be detachable. This should be washed away with a 2 per cent solution of caustic potash, and the sterilising process repeated. For the next two days compresses of sterilised water are kept on. On the night before the operation the knee and the parts near are washed with caustic potash again, then with soap and water, ether, methylated spirit, and a compress of an alcoholic solution of 1 in 1000 biniodide of mercury put on. The surgeon himself must attend personally to the sterilisation of instruments, swabs, ligatures, and dressings. Before the operation, the surgeon sterilises his hands and arms with the utmost care by washing them for ten minutes in soap and water, then he steeps them in 1 in 1000 watery solution of biniodide of mercury for five minutes, succeeded by 1 in 500 alcoholic solution of biniodide of mercury for another five minutes. The assistant and the nurse carry out the same routine. To make assurance doubly sure, rubber gloves, previously boiled and rendered sterile, and masks are put on by all three. It is generally advisable to use a tourniquet, which is put on before the compresses are removed. The bandages covering the compress are then taken away, sterilised cloths are wrapped round the surgically clean foot and the lower half of the leg and the thigh. Then a wide sheet of sterilised cloth, with a cut of twelve inches in it, is slipped up to the middle of the patient's thigh, so that it effectually shuts off the field of operation from the surroundings. Mr. Jones has found that the best view of the interior of the joint is obtained by allowing the leg to hang at right angles over the edge of the table.

The operation is now proceeded with, and a vertical or a

wire protruding from the skin. All went absolutely well for a month, and then a little suppuration formed around the ends of the wire. The wire was immediately removed, but the suppuration spread, and in a short time the joint was involved. This was opened, pus was evacuated, but the condition became worse. He refused amputation and died. The interest of the case lies in the results revealed at the post-mortem examination. At the lower end of the opposite tibia there was found a chronic abscess of bone, the cavity containing about half a drachm of fœtid pus. The man himself had not mentioned any trouble here at all, so that it was not suspected. I cannot help thinking that the infection which took place in the skin a month afterwards was in no way due to external causes, but to the presence of staphylococci circulating in the blood.

semilunar incision with the convexity backwards from two and a half to three inches in extent is made with its centre about an inch from the inner side of the patella, the knee being flexed to a right angle. The joint is opened, and the interior inspected. If the cartilage is found in any way altered it should be removed, and even if it be found unaltered, if the history is a characteristic one, it should be taken away, as it is impossible to say whether it is or is not loosely bound down. Removal of the cartilage is effected by means of a suitably curved pair of scissors, and with a little care and manipulation the greater part of the internal semilunar may be excised. Under no circumstances whatsoever should the surgeon insert his fingers into the joint. The tourniquet is now loosened, and the blood-vessels secured and twisted, but not tied. No silk or any foreign material is to be introduced into the interior of the joint. The synovial membrane and capsule are sewn up, and subsequently the skin is separately sutured. For this purpose it is better to use silkworm gut threaded with a needle at each end, and the sutures are passed from the deep surface outwards on either side. The wound is closed and sterile dressings are applied. We place the limb, somewhat flexed at the knee, on a pillow in the bed, and steady it by sand-bags. We do not use a splint, as we find the stiffness after the operation is greater, lasts longer, and is more difficult to get rid of.

In some instances, on the second day there is a rise of temperature to 100° or 101°, and this may cause the surgeon a little apprehension. However, as a rule the temperature falls on the third day, if the bowels are well opened. Should it not do so, a sterilised director may be introduced through the wound into the interior of the joint, when a little clear fluid escapes, and the temperature falls in a few hours.

On the tenth day, the stitches are removed and the knee is massaged. From the tenth to the fourteenth day gentle flexion of the joint is made, and about the end of the third week the patient is able to take exercise. When the wound is healed, and while the patient is at rest, massage to the muscles of the thigh and leg is called for.

Morrant Baker's Cysts of the Knee-Joint.[1]—The cysts may be situated in the popliteal space, or even at a distance from the joint as far as the middle of the leg. They are of a simple serous

[1] *St. Bartholomew's Hospital Reports*, vol. xiii. p. 245, vol. xxi. p. 177 ; and *Centralbl. f. Chir.*, 1898, p. 585.

nature, and by careful and minute dissection it can be shown that they communicate with the joint. It is often impossible to obtain fluctuation between the cyst and the joint, nor can fluid be forced from one to the other.

They are doubtless due to an extension of the synovial membrane, probably developmental. They give rise to considerable difficulty in diagnosis. The only treatment is extirpation of the cyst.

Irritability of the Knee, due to Short Legs, Asymmetry of the Limbs, Right-angled Contraction of the Tendo Achillis, and Flat Feet.—In all these conditions, where an exceptional strain is thrown upon the knee-joint, weariness, pain, and slight effusion into the joint may take place from time to time, and are relieved by the discovery of the cause and its treatment.

A case which the writer recalls was that of a man who came to him from Paraguay with frequently disabling attacks of synovitis. He was completely cured by a thickened sole of half an inch on the boot of the affected limb, which was short by that amount.

Recurrent Dislocations

The Temporo-Maxillary Articulation.—This is a particularly troublesome form, and may give rise to considerable physical and mental distress. The dislocation may be partial or complete. More often it is partial and accompanied by considerable pain. Two such cases have come under the writer's notice, in which permanent relief was obtained by operation.

Case 17.—A lady, aged 45 years, suffered for four years from partial displacement of the condyle whenever she opened her mouth or ate solid food. It so preyed upon her that she had become melancholic, and was ready to submit to any form of operation. In her case I exposed the joint, drilled a hole through the neck of the condyle from before backwards by means of a specially constructed drill, and a second hole through the lower root of the zygoma. A wire was then passed through the neck of the condyle and the zygoma, and tightened so as to keep the jaw in place (Fig. 264). The patient was fed at first on fluid diet, and then movement gradually allowed. During the twelfth week after the operation, the wire was removed, and the patient has never had any trouble since.

Case 18.—The second instance was that of a man aged 30 years, who had suffered from similar symptoms for two years. In his case the neck of the condyle was pierced, stout silkworm gut passed through the aperture, and secured to the zygoma itself, merely being firmly tied round it. It was left permanently *in situ*, and the patient was extremely satisfied with the result.

The writer can strongly recommend this operation as a remedy for a very annoying condition.

Recurrent Dislocation of the Shoulder.—As at the hip and knee, this is often due to laxity and weakness of the muscles, especially the deltoid, following infantile paralysis, and in adults it occasionally follows a traumatic dislocation. It appears that in these cases the capsule has been extensively torn, and the joint has been used prematurely, so that the capsule has remained lax.[1]

Thus the writer has now under his care a gentleman who has a partial subluxation backwards of the head of the bone, whenever he brings the arm forwards and raises it. Some two years ago he sustained a subspinous dislocation. In his case there is some

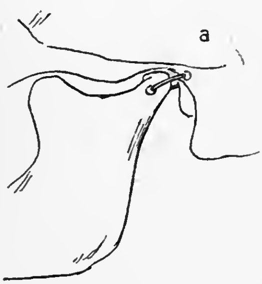


FIG. 264.

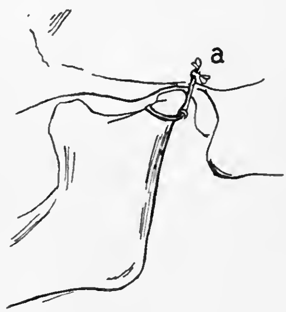


FIG. 265.

Two diagrams, illustrating the author's operation for Recurrent Dislocation of the Jaw Forward. In Fig. 264 the wire or silk-worm gut is passed through apertures in the neck of the condyle and root of the zygoma. In Fig. 265 they are passed around the condyle and the arch of the zygoma.

wasting of the supraspinatus and the infraspinatus, and it is a striking fact that many of these cases of recurrent dislocation of the shoulder are accompanied by atrophy of the muscles around the joint.[2]

Other causes of recurrent dislocation are partial fracture of the glenoid cavity; tearing away of muscular insertions, followed by feeble union; and partial fracture of the head of the humerus, or

[1] This is the view accepted by the majority. Yet it must be remembered that the head of the humerus is kept in position normally by the muscles, and that the capsule is a very lax structure. It is true that shortening the capsule in these cases is a more or less successful procedure, but it is no proof that the ligaments are at fault. Arthrodesis is a successful procedure too, yet it is only successful by doing away with the normal condition of mobility of the joint.

[2] Burrell and Lovett, *Amer. Jour. of Med. Sci.*, August 1897.

impacted fracture of the anatomical neck in bad position. The disablement is also met with in syringomyelia.[1]

Prognosis.—When the dislocation has occurred several times, palliative treatment is often of little avail, for, as time progresses, slighter causes induce the displacement. Sometimes this lesion may distinctly endanger life, as occurred in a case which came under the writer's knowledge, when it happened during swimming, and the lady was nearly drowned. Reduction is by no means always easy. Thus in a case recorded by Witius[2] of an epileptic[3] whose shoulder was luxated no less than fifty-four times, it was not always possible to get it back without an anæsthetic.

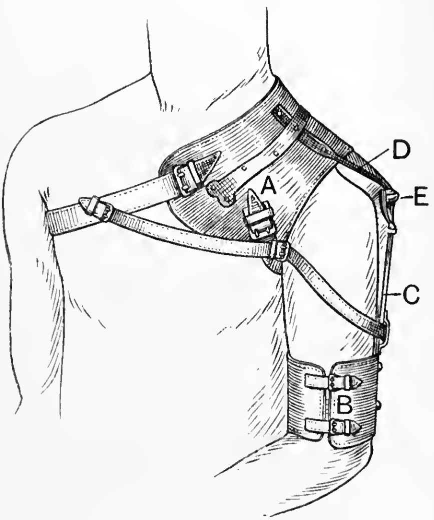


FIG. 266.—Ernst's Apparatus for Recurrent Dislocation of the Shoulder. A, Saddle shoulder-piece or fulcrum; B, Upper-arm band, connected to saddle shoulder-piece by stems C and D, having ball and socket limited movement at E.

Treatment is either palliative or operative.

In the palliative form the apparatus (see Fig. 266) is fixed to the shoulder and chest, allows limited antero-posterior movement, but effectually prevents abduction, when dislocation usually happens.

Whenever palliative treatment is undertaken, the muscles must be massaged and electrically stimulated, not only to prevent atrophy, but also to endeavour to brace up the ligamentous structures of the joint. In those cases where it is evident that the cause at work is laxity of the capsule, following a traumatic dislocation, an injection of a few minims of absolute alcohol beneath the muscle and around the capsule is worthy of trial.

[1] Zesas states that in tabes, joint affections are met with chiefly in the lower extremity, while in syringomyelia the arm joints are those involved, especially the shoulder; and the changes lead to habitual luxation in it,—a point of diagnostic importance, for it is an early sign.

[2] *Münchener med. Wochenschr.*, 1905, N. 33.

[3] A history of epilepsy is so often met with in recurrent dislocation of the shoulder that it must be looked on as a predisposing cause.

It should be repeated several times, and the parts kept at rest in the intervals.

If all other methods have failed, and the patient's arm is rendered useless, or his occupation is seriously interfered with, it is advisable to cut down on to the joint by a vertical incision, and "pleat" the capsule. Whether the incision is placed anteriorly, exteriorly, or posteriorly, will depend upon an appreciation of the clinical signs, showing which portion of the capsule is lax. The operation is often very successful.

Subluxation at the Symphysis Pubis.—During pregnancy the ligaments of this joint become softened and relaxed, so that a sense of insecurity results, and the patient is unable to walk in comfort. As a rule, however, the abnormal condition disappears after delivery, but, if it should persist, the patient should be fitted with a wide pelvic band.

Recurrent Dislocation of the Patella.—A slipping patella may follow a traumatic dislocation, in which the fibres of the inner portion of the capsule have been unduly stretched. It is more commonly associated with weakness of the extensor cruris muscle and laxity of the ligamentum patellæ. The displacement is almost invariably to the outer side. Normally the line of action of the quadriceps femoris forms, internally, a slight angle with the line of the ligamentum patellæ, so that when the latter is tense the patella is thrown slightly to the outer side of the leg. Its displacement outwards is prevented by the projection of the anterior surface of the external condyle. Now if the tubercle of the tibia is displaced outwards, as in genu valgum, or if there is laxity of the quadriceps or of the ligamentum patellæ, the prominence of the external condylar surface of the femur is not sufficient to arrest the outward passage of the patella, and it becomes subluxated or dislocated. The arresting influence of this ridge of bone is lost in hyper-extension of the knee, where the patella cannot be kept closely applied to the femur. It therefore follows that we meet with this displacement under the following conditions:—Genu valgum, where the tubercle of the tibia is displaced outwards, in paralysis of the extensor cruris muscle, in some rickety children, where hyper-extension of the knee takes place, and in girls of weak muscular development. These causes are in addition to the post-traumatic form. Very slight strain or injury is quite sufficient to produce the lesion, and as time goes on it becomes more and more frequent.

The displacement is accompanied by excruciating pain, and the patient either falls or is unable to use the leg. A considerable degree of synovitis follows, and as this results in increasing weakness of the ligaments the condition becomes more frequent.

The patient can frequently reduce the dislocation himself; if not, the leg should be fully extended, and even hyper-extended, and the patella pushed into place. In those rare cases where the patella is not only displaced, but is twisted, so that its outer edge rests against the front of the femur, replacement is difficult.

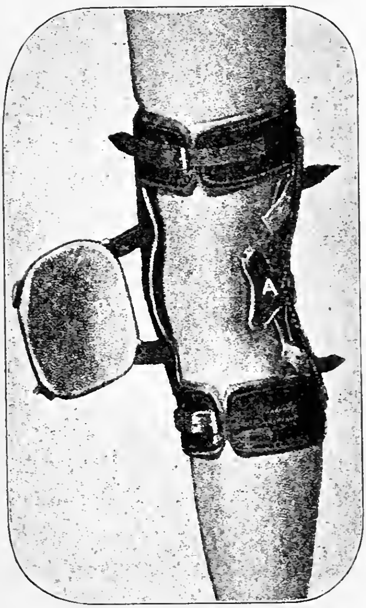


Fig. 267.—Ernst's apparatus for Recurrent Dislocation of the Patella. Note the crescent-shaped supporting plate at A, which prevents dislocation of the patella. When the apparatus is applied, the knee-cap, B, lies over the patella.

Treatment. — We should be quite clear as to the exact cause. It is sufficient, if genu valgum is present, to cure it and thus remove the liability to recurrent dislocation; whilst in rickety children and anæmic girls, massage of the muscles, avoidance of fatigue, and a proper amount of rest, will often suffice to brace up the parts to such an extent as to prevent further trouble.

It is also necessary, however, to decide whether the case should be treated by mechanical support or by operation.

Mechanically it can be treated by means of a knee-support constructed of two lateral vertical uprights hinged opposite the joint, and connected above and below by steel half-bands and straps. Attached to the vertical uprights are semilunar pads, which press upon the patella and keep it in place; and these pads may be further kept in contact with the patella by straps passing obliquely over the front of them and of the joint (Fig. 267). It is advisable to limit the amount of flexion movement; otherwise the apparatus becomes ineffectual, because as the patella sinks into the inter-condyloid notch the pads can no longer grip it.

Operative Treatment.—Several operations are practised, but that one, which the writer has found to be entirely effectual in several cases in which he has employed it, is the following:—

A transverse incision is made two fingers' breadth above the patella, exposing the quadriceps tendon. A pleat half an inch to one inch deep is then taken up in the tendon and muscle-substance of the extensor cruris. The width of the pleat should be gauged by the looseness of the patellar tendon when the leg is in extension, but not in hyper-extension; and the pleat should extend on either side to at least half an inch beyond the inner and outer edges of the patella. Fine silk is used for the pleating, and

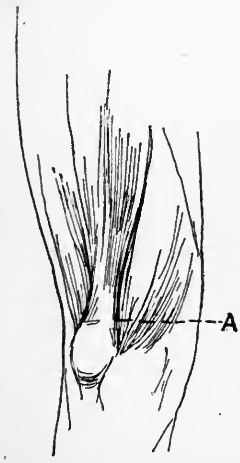


FIG. 268.—Author's operation of pleating the quadriceps extensor tendon for recurrent dislocation of the patella. A, The relaxed quadriceps tendon.

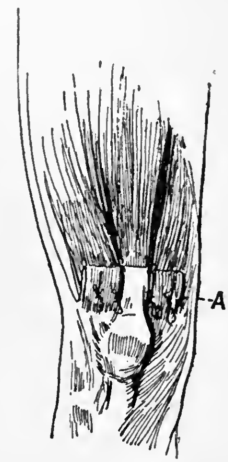


FIG. 269.—The operation completed. A, The quadriceps tendon has been tightened by pleating.

four to six sutures are inserted (Figs. 268, 269). Healing takes place in a week to ten days after the operation, and the limb is kept at rest on a back splint for a month, after which movement is gradually permitted.

Surgeons have also transplanted the tubercle of the tibia internally, so as to obliterate the angle formed by the axes of the line of action of the extensor tendon and ligamentum patellæ. Another method is the removal of an elliptical portion of the capsule of the joint internally to the extensor tendon, and stitching together the edges of the opening.[1] The writer, however, has been

[1] *New York Med. Rec.*, April 20, 1895; *Transac. of Amer. Orth. Assoc.* vol. viii. pp. 227 and 237.

completely satisfied with the form of operation he has originated, and sees no necessity to carry out the more extensive procedures. It is certain that when the extensor tendon is pleated in the way indicated, hyper-extension of the knee and recurrent dislocation disappear.

Ankylosis

By ankylosis is meant permanent stiffening of the joint, due to bony, articular, and ligamentous changes. According to the point of view taken—whether clinical, pathological, or therapeutic—the various forms are classified, but, before mentioning the varieties, it is essential to render clear this point, that all stiffness of joints is not ankylosis. Thus rigidity of a part, due to involuntary contraction of muscles in joint disease, entirely disappears under anæsthesia, and is therefore called "false" ankylosis. Contracture, however, is an advanced condition of contraction, and the loss of mobility of the joint is then due to permanent shortening of muscles, tendons, fasciæ, and skin. It is true that these changes are associated with ankylosis in vicious positions arising from joint disease, but they are also met with where no sign of arthritic change is present, as in spastic and infantile paralysis and hysteria. The term "contracture" is therefore in no sense synonymous with ankylosis, and the conditions should be carefully distinguished. "Ankylosis" is limited to those conditions of stiffness or immobility of the joint which result from changes involving the articular surfaces. Thus true ankylosis is distinguished from false. The true form may be complete, when all motion is lost, or incomplete, when some movement remains.

Pathologically, fibrous, cartilaginous, and bony forms are met with.

In the first named, bands of fibrous tissue form between the joint surfaces, and such bands may be loose or tight, localised or diffuse; upon their extent and length depends the degree of movement of which the joint is capable. Fibrous ankylosis arises from injuries, such as dislocation and fracture into the joints, from pyogenic, gonorrhœal, tuberculous, rheumatic, or gouty affections.

Cartilaginous ankylosis is due to the fusion of two opposed cartilaginous surfaces. The best example is union of the patella to the femur and tibia in some forms of tuberculous disease of the knee-joint. It causes absolute stiffness of the joint.

Bony ankylosis implies osseous union between the articular surfaces or synostosis. It is usually the result of suppuration in the joint, whether pyogenic, gonorrhœal, or tuberculous. It is also met with in non-suppurative affections, such as syphilitic and gouty arthritis.

In arthritis deformans, bony ankylosis occurs, particularly in the vertebral articulations, by the interlocking of osteophytes, and by the ossification of adjacent ligaments. This variety is sometimes known as external or peripheral ankylosis. Therefore another classification appears, namely, the intra- and extra-articular, which explain themselves. Clinically we are indebted to the late H. O. Thomas for an original nomenclature, the unsound and the sound.[1] By the "unsound" he meant ankylosis where the inflammatory changes have not subsided, whilst a sound ankylosis implies the absence of active disease. The value of this distinction is very great from a therapeutic point of view, and this classification applies more particularly to ankylosis of the fibrous variety. The distinction between the two conditions is that in a sound ankylosis the flexion angle will not be altered by use, because all inflammatory changes have subsided; whereas in an unsound ankylosis it constantly increases until the extreme limit of deformity is reached. This is best illustrated by considering what may happen in a case of chronic hip-joint disease, in which the angle of flexion deformity is, for example, 15 degrees. If the fixation of the joint be partially removed, and the patient be allowed to go about for a few weeks, and the angle of deformity is then found to have increased to 25 degrees, there can be no doubt that we are dealing with an unsound joint and an unsound ankylosis. A very rare form of ankylosis is also met with congenitally.

It is a well-ascertained fact that the disuse of a healthy joint, so long as it is not indefinitely prolonged, does not give rise to ankylosis in the true sense of the word, and this has been placed on an indisputable basis by the researches of Hulke, Paget, and Reyher.[2] Dr. Griffiths of Cambridge has drawn attention to a variety of joint fixation arising from what he designates as arthritic ossificans, which is associated with other trophic changes of unknown origin in the osseous system.

The causes of true ankylosis are acute and chronic joint-inflammation, whether traumatic, suppurative, or non-suppurative, and

[1] "Ankylosis of Joints," *Med. Annual*, 1900, p. 292 (Robert Jones and A. H. Tubby).

[2] *Deut. Zeit. f. Chir.* iii. 1873.

special emphasis is laid upon the word "joint." The so-called false or extra-articular ankylosis arises from changes entirely outside the capsule, and is due to stiffening and shortening of the soft peri-articular tissues, whether ligamentous, muscular, tendinous, fascial, or cutaneous.

Ankylosis is not always an undesirable pathological condition, and may be looked on in some instances as a reparative process. It may be welcomed in marked tuberculous disease of the hip and knee, provided that the parts are immobile in the most useful positions. In a limb in which one or more joints are partially immobile, definite changes are noticed. It is shorter and smaller than its fellow; considerable wasting and some coldness are present, and, if there is contraction, it is seen on the flexor aspect, where the muscles are found to be shortened and their tendons tight, whilst the more superficial structures, such as the fasciæ and the skin, are also contracted.

Prevention of Ankylosis.—The danger may be lessened or avoided by the proper treatment of the primary cause. Suppurating joints should be opened early and drained. Immobility should not be too prolonged after fractures into joints. Passive movements and manipulation will eliminate the risk of ankylosis from arthritis deformans. In tuberculous disease, early and efficient protection and fixation will limit the extent of the morbid process, and prevent wide destruction. Whitman remarks [1] that "formerly it was believed that prolonged fixation of a diseased joint would of itself induce ankylosis, but now that it is known that final limitation of motion is dependent upon the severity and the duration of the disease, prolonged rest of tuberculous joints is believed to be the most efficient means of securing motion. When the disease is cured, functional use will ordinarily restore all the motion of which the part is capable."

The extent of the ankylosis may be estimated by a consideration of the cause, by examination under an anæsthetic, by skiagraphy, and by manipulation of the part. In the fibrous variety, even though there be sound ankylosis present, forcible movement of the joint beyond a certain well-defined point, causes pain, while in osseous ankylosis no discomfort arises. In cases where doubt exists as to the fibrous or osseous nature of the ankylosis, examination by skiagraphy and under an anæsthetic will give the requisite information.

[1] *Orthopedic Surgery*, 2nd ed. p. 287.

Prognosis. — *As to the Probability of Ankylosis occurring in a Case.*—This must depend upon the nature of the cause at work and the character of the treatment. Briefly, it may be said that suppurative conditions are more likely to end in bony ankylosis and tuberculous conditions in fibrous; in fact, it is unusual to secure bony ankylosis in the latter disease. What may appear clinically to be bony ankylosis is often found to be incomplete. Externally there is a thin shell of new bone, while internally the space between the articular ends is occupied by closely-packed fibrous tissue. When ankylosis has occurred, if it be of the bony variety, we have to consider whether the limb is in a favourable position or not; and, unless there are powerful reasons to the contrary, it is often wise to let matters remain as they are. The question of dealing, however, with fibrous ankylosis is another matter, and here we appreciate the value of the clinical distinction between sound and unsound ankylosis. If movement is not followed by further limitation of the functions of the joint, then the prognosis is good; and, naturally, the contrary applies. Except in carefully selected cases, and by the use of most judicious treatment, fibrous ankylosis is more likely to be rendered worse than better by forcible movements, which often end in disaster. Partially ankylosed joints must be coaxed into movement, and not forced.

Treatment.—Two conditions stand out clearly when we consider the treatment of ankylosis, namely, the existence of the fibrous and the bony forms; and the lines to be followed are widely divergent.

Treatment of Fibrous Ankylosis.—Having ascertained that all acute or subacute inflammatory states have passed away, we gradually stretch the adhesions and promote the nutrition of the joint. We bathe the part with water as hot as it can be borne for several minutes, then massage the joint, and stretch it manually, using no sort of violence. If much force is used, or if gentle stretching is applied too frequently, inflammation may start in the joint again, and the last condition be worse than the first. The amount of manual stretching which can be safely employed is estimated by observing if there is a daily increase of movement, without constant pain. Much assistance can be gained in some cases by hot-air baths, vibratory massage, and by Bier's congestive method. The entire co-operation of the patient is essential. He should be persevering, able and willing to face discomfort and pain.

Of especial value is treatment by various forms of electricity. We have found the electric light bath very useful, and particularly ionisation. We have asked Dr. Howard Humphris to supply us with some remarks on the subject, and he has kindly done so:—

THE TREATMENT BY IONISATION OF CHRONIC STIFFNESS OF JOINTS

"In all incomplete ankylosis there exists one common factor, either causative or concomitant, and that is a fibro-sclerosis. It may be that all the stiffness is due to this sclerosis, in which case it can be lessened and even removed by ionisation in proportion as the fibroid process enters into the pathology. A skiagram should aid the prognosis considerably.

"These short notes confine themselves to those cases of stiffness, of more or less long standing, which are due to the existence of sclerosis or cicatricial tissue. In Ionic Medication we have a remedy which has the power of resolving this tissue. Seventeen years ago Professor Stephane Léduc suggested this method, and it has been gradually gaining ground ever since. It is simple and well within the reach of every medical man. All that is required is an ordinary galvanic battery (the cells should be of large size so that the internal resistance may be as low as possible—there should be 20 to 30 of them connected in series, having in all a potential of 30 to 40 volts), a rheostat whereby the current can be gently and steadily graduated or regulated, a milliamperemeter to measure the current, connecting cords, absorbent lint, and pieces of some pliable metal, such as sheet tin or Crooke's composition, an alloy of lead and tin, some common salt, and sterile water.

"The theory of ionic medication is too complicated to discuss here. In brief, we know that when a constant current is passed through a salt in solution, the constituents of that salt are set free, and they travel, or have a tendency to travel from one pole to the other, hence Faraday called them 'ions' or travellers. That the introduction of these ions is possible is easily proved by using strychnine or cyanide of potassium on a rabbit, when the animal in the former case will be seized with ordinary strychnine convulsions, and in the latter will die instantly. Again, if any part of the human body be painted with tincture of iodine and the negative current applied, the brown stain will disappear from the skin.

"Certain constituents are set free at the negative pole and others at the positive pole. Speaking generally, the ions of metals are liberated at the positive pole and the ions of non-metals at the negative pole. Thus chloride of sodium in solution is split up, the ions of chlorine gathering at the negative pole, and the ions of the metal sodium at the positive. The chlorine ions have the property of resolving the fibrous tissue which is causing the ankylosis. It is upon this sclerolytic property that the ionic treatment of ankylosed joints depends.

"The technique has been described in vol. ii. p. 456.

"The treatment should last about 30 minutes, and be continued thrice weekly, decreasing the frequency *pari passu* with the improvement in the patient to twice weekly and then once a week. Improvement will be noted from the beginning, the patient will observe the increasing freedom of movement, a more general feeling of flexibility, and in many of the painful varieties of arthritis a diminution of the pain.

"One practical point may be noticed. It sometimes happens that, as soon as the current is turned on, the patient will complain immediately of a stinging pain. This will be found due to some skin abrasion, such as a scratch; the current should be turned off, the electrode removed, and the lesion should be covered with a drop of collodion, when the treatment may be resumed in comfort. Another point is that rings should be taken off, the non-observance of this precaution may lead to a burn. In my own practice, a patient, with a stiffened right hand, to which I was applying chlorine ions, had placed the left hand in plain sterile water, in which was a carbon terminal, to act as the indifferent electrode. After passing a current of 25 ma. for thirty minutes, a burn developed under the wedding ring, which healed up with difficulty. It may be mentioned that not only on joints can this method be used, but also in ophthalmic troubles where this fibro-sclerotic tissue exists, such as rheumatic scleritis and periscleritis, and in other diseases such as pleurisy, where the pain depends upon adhesion; in fact, wherever we know that the pathological condition is caused by or accompanied with fibrous tissue, the electric sclerolysis with the ions of chlorine may be used with advantage. I append a brief resumé of six cases, the first three reported by Prof. Léduc, and the last three from my own practice:—

"'1. A complete ankylosis of the fingers, following an abscess of the hand, in a young soldier who was treated in a military hospital for six months by different methods. As there was no improvement, he was dismissed the Army. After two electrolytic séances, with his hand in a bath of a solution of chloride of sodium, which took the place of the kathode, for a period of 30 minutes with a current of 30 milliamperes, he recovered the power of movement so completely that no trace of ankylosis remained.

"'2. A state forester, after six months of immobilization for a phlegmonous arthritis, had his knee completely ankylosed for five months. After two months' treatment, consisting of nine electrolytic séances, each of which lasted forty minutes, with a kathodic compress impregnated with sodium chloride and a current of 100 milliamperes, he could walk perfectly. He was able to resume his duties, which he has continued without interruption ever since. The treatment began with two séances per week, which were subsequently diminished to one per week, and then one every fortnight.

"'3. A young woman had an ankylosed knee-joint after typhoid fever. It was a very painful variety of chronic arthritis, which had remained unaltered for eighteen months. After twelve electric séances, with a kathode applied to the knee, the pain disappeared, as well as all thickening of the tissues, and the movements became free.'

"4. Patient was a lady aged 59 years. She complained of a 'gouty hand, especially the thumb,' which she could not use much. She said the bone seemed sore, and it ached, especially after using it. The trouble had lasted four years and was getting worse. I administered chlorine ions to the hand complained of, placing the other in a bowl of water as the indifferent electrode; the current strength was 30 ma., and was allowed to flow for thirty minutes, thrice weekly. Improvement was marked from the first, and patient had very little stiffness and no pain at the end of a month.

"5. Patient was a lady aged 89 years. When she was 35 years of age, all the small joints of the fingers were swollen and painful. Since that attack there has been no pain, but the joints remained stiffened. Two months ago the joints became painful again. Both hands were immersed in the salt solution, and the feet placed in a foot-bath of sterile water with a carbon electrode. The patient easily tolerated 30 ma. for thirty minutes. After the second treatment, she said that her hand felt more lissom, and that she was able to write more easily. After six ionic medications there was no pain, and members of the patient's family noticed that her handwriting was more firm and resembled her former writing. The joints moved much more freely. In this case, as in some others, there was a temporary but painless swelling, which reached its height twenty-four hours after the introductions of the ions, due to the reaction of the fibrous tissue to the resolvent action of the ions. The swelling subsided of its own accord, leaving the joints in an improved condition. After two months' treatment there was no pain whatever, and movements were much more free.

"6. Patient was a lady aged 60 years. She had an attack of 'gout' in the right knee three years ago, when she was confined in her bed for one week. Since then any exercise causes pain. There was, on examination, a chronic synovitis with limitation of movement due to the thickening of the capsule and ligaments. The joint was bound with saturated lint, the foot of the same side was put into a bath, acting as the indifferent electrode, and a current of 35 ma. was administered for thirty minutes. This was repeated for six times, with intervals of three days, and then the patient left London with no perceptible difficulty in walking, and complaining of no pain.

"I am not claiming for this method of treatment that it is the only agent we have, or that there are not other forms of treatment which may be employed with advantage. 'It is not the agent . . . but the reaction of living tissues to an agent' upon which we depend for rational and successful treatment. This much may be safely claimed for the ionic method of medication, that it is easily employed, the local trouble has local treatment, it is painless, it has no ill effects, and no time is lost in waiting for results, as improvement is evident from the first. And, finally, it places a method of treatment within the reach of any intelligent practitioner, a method of treatment for a troublesome and chronic affection, for which too often the patient is told that nothing can be done."

Mechanical measures by adjustable splints, ratchets, and screws, and weight-extension, are valuable adjuncts. The measures which we have just indicated are suitable to limitation of joint movements such as follows fractures and joint injuries, or as is seen in the course of arthritis deformans, and after non-tuberculous inflammation in and around the joint.

Forcible Stretching under Anæsthetics.—If the surgeon sets out with the determination to secure movement at all hazards disaster is likely to follow, and, in any event, more harm than good is done to the part. When the patient is fully anæsthetised, the conditions within the joint may be readily appreciated. If with gentle limited movements adhesions suddenly give way, then the outlook is satisfactory. But if there be continuous resistance, which cannot be overcome by gentle movements, then it is useless to proceed. And even if the adhesions are broken down by using great force, the ultimate condition of the patient is often as bad, or worse, than before. The accidents attending forcible correction of ankylosed joints, or *brisement forcé*, have been very numerous. Separation of the epiphysis, fat embolism, lighting up of the original disease, rupture of arteries and veins, gangrene in the limb and permanent paralysis from nerve-stretching, have all followed. In dealing with tuberculous joints no forcible movements should be attempted during the progress of the disease, nor for a long time afterwards, and even then any movements, which are made, should be tentative and gradual. If it be found that the range of previous movement has decreased after gentle manipulation, then all efforts must be discontinued. In non-tuberculous joints, after movement under an anæsthetic, when there is very little reaction, massage and passive motion may be used at once; but if pain and swelling follow the operation, it is best to fix the joint until such symptoms have subsided. In some cases of fibrous ankylosis it may be advisable to open the joint, divide and remove adhesions, or it may be possible to take away interlocking osteophytes, or to remove troublesome exostoses. Good results have followed these procedures. In cases of fibrous ankylosis it is advisable to divide contracted muscles, tendons, and fasciæ before movements of the joint are attempted.

Bony Ankylosis.—This can only be dealt with by operation. The position of the limb can be corrected by osteotomy, using a linear or wedge-shaped section of the bone, or by an excision.

Formation of New Joints.—A most instructive treatise by Huguier[1] on the operative treatment of bony ankylosis has placed the consideration of this subject on a sound surgical basis. It is one which must be approached carefully, and it is useless to make a new joint if the stability of the limb is thereby destroyed. It is equally futile to form a ne-arthrosis if the result is to be that the limb renders less service to the individual than when it was ankylosed. It therefore follows that there are conditions of bony ankylosis in good position in which it is not permissible to interfere. It is also equally certain that there are some cases of vicious ankylosis in which an operation will merely serve to refix the joint in good position. Finally, there are cases in which it is either indispensable or preferable to re-establish the mobility of an articulation in order to increase the utility of the limb. According to Ollier three postulates are demanded for the re-constitution of an articulation:—

1. To prevent the contact of the two surfaces of newly-cut bone. A sufficiently wide area must be removed, so that the effects of reflex contraction of the muscles in drawing the fragments together are neutralised. A sufficient space must be left between the cut surfaces of bone for the interposition of soft tissues.

2. The re-formation of new bone in the interfragmentary spaces must be prevented; and this is effected by taking away the periosteum corresponding to the portion of bone removed.

3. This is the most important postulate of all. A serous bursa must be formed between the osseous fragments to secure permanent mobility.

The first two requirements present no extreme difficulty, but the selection of tissue for the production of a serous bursa needs careful consideration. Foreign bodies, such as plates of magnesium, ivory, and various kinds of metallic substances, have been tried and found wanting. Skin and subcutaneous tissues are not satisfactory, because of the difficulty of rendering them thoroughly aseptic and of transplanting them in sufficient amount. Flaps of aponeuroses are too feebly nourished with blood to undergo the transformation into bursal tissues. Dr. Huguier strongly advocates muscular tissue covered by aponeurosis and fat, and his view is supported by the experience and writings of J. B. Murphy of Chicago

[1] "Traitement des ankyloses par la résection orthopédique," par le Docteur Alphonse Huguier, Paris, 1905. A. H. Tubby, *Practitioner*, Feb. 1907, p. 252, "Ankylosis and its Operative Treatment."

in his article on "Ankylosis and Arthroplasia, Clinical and Experimental."[1]

Before undertaking an operation for the re-formation of a joint we ought to consider carefully what pathological condition has been the cause of the ankylosis. Briefly, it may be said that the reaction of the tissues after an operation for ne-arthrosis depends very much upon the nature of the original disease. Such disorders as gonorrhœa and infective arthritis increase greatly the osteogenetic activity of the bone cells, and impart to the fibrous tissues in the neighbourhood such a tendency to persistent contraction, extending over a very long period, that the possibility of the recurrence of ankylosis, even after the formation of a new joint, is very great.

In the ankylosis consecutive to tuberculous disease, the tissues have acquired characters quite different from those found in the disorders just mentioned. Tuberculous arthritis is accompanied by a comparatively small amount of development of bone, and by the formation of but few bands of firm fibrous tissue. So that the sufferers from this disease are, when the tuberculous trouble has entirely subsided, very fit objects for operations designed to form mobile joints.

Another serious question is the age of the patient. After thirty years of age the power of the periosteum and bone cells to develop new bone becomes less active, and therefore re-ankylosis is less to be feared.[2]

With these preliminary remarks on this interesting subject, we now pass on to consider in detail the treatment of fibrous and bony ankylosis of the various joints.

The Temporo-Maxillary Articulation.—A mild degree of fibrous ankylosis of one or both joints is not of very serious import so long as the patient retains sufficient movement to masticate the food. But, the condition is a very distressing one when either close fibrous ankylosis or bony ankylosis is present. For close fibrous ankylosis excision of the condyle is of service, and even when the condition is bilateral this operation, done on one side, improves the

[1] *Jour. of the Amer. Med. Assoc.*, May 20, 1905, p. 1573. The superiority of muscle consists in the fact that, unlike skin, it is aseptic from the first ; it is near the joints ; its vascular supply is exceedingly good, and it therefore bears partial detachment and transplantation extremely well. The selection of muscular tissue depends upon a recognition of the fact that the interposition of fibres of this nature is one of the most potent causes of non-union of fracture.

[2] The literature on this subject will be found in Dr. Huguier's publication, and in the article by Dr. Murphy, *Transac. of the Amer. Surg. Assoc.* xxii. p. 315.

state of affairs materially. However, when bilateral bony union is present, it is found that resection of the joints alone usually results in re-appearance of the trouble. The formation of ne-arthroses is essential; and for this purpose either the condyles, with or without the coronoid processes, are removed, or the ramus of the jaw is sawn through and strips of the temporal or masseter muscles interposed (Figs. 284, 285). Before embarking on the operation, a laryngotomy or tracheotomy is usually done, in view of the danger to the patient if he should happen to vomit during the operation, or become embarrassed by a collection of blood in the pharynx, when the ramus is sawn through. Dr. Huguier recommends, for removal of the condyles, an incision commencing two fingers' breadth in front of the tragus, and three fingers' breadth above the zygoma. From that point the knife is carried vertically down to a little below the zygoma, and then backward nearly to the tragus. The results which have followed this operation fully justify the procedure.[1]

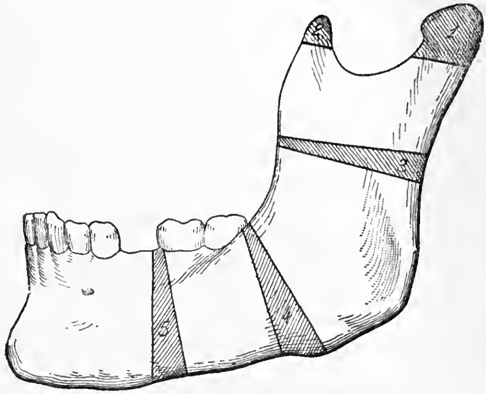


Fig. 270.—Resections practised for the relief of Ankylosis of the Temporo-Maxillary Articulation (Huguier). 1. Resection of the condyle; 2. Resection of the coronoid process; 3. Osteotomy of the ascending ramus (Rochet); 4. Osteotomy at the junction of the body and ascending ramus (Levrat); 5. Osteotomy of the body of the inferior maxilla (Esmarch-Rizzoli).

Shoulder.—The most common form of partial or fibrous ankylosis in the shoulder is that following a fall on the shoulder, with a bruised deltoid and effusion into the joint, and the subsequent appearance of intra-articular fibrous bands. If it be found that movement is slow in returning, the part remains partially powerless, and other mild measures are not efficacious, then the joint should be moved under an anæsthetic. Too much force should not be employed, otherwise dislocation and rupture of vessels and nerves may follow; and the surgeon should be content at the first sitting with obtaining partial movement, more especially if he can

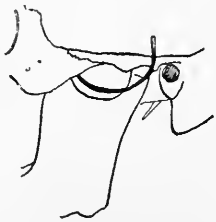
[1] For full details of the operation see Dr. Huguier's treatise, and Figs. 283-285 in this volume depict the essential steps of the operation.

Bottini.
FIG. 271.

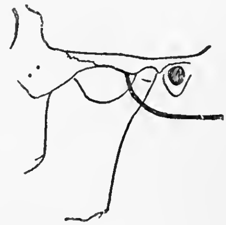
Ranke.
FIG. 272.

Richet.
FIG. 273.

Delbet.
FIG. 274.

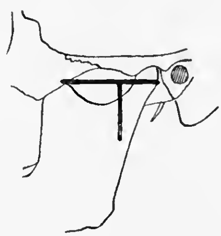


Humphry.
FIG. 275.



Bassini.
FIG. 276.

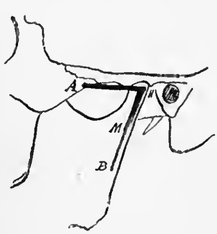
König.
FIG. 277.



Ollier.
FIG. 278.

Abbe, Pughe.
FIG. 279.

Chavasse.
FIG. 280.



Lippe, Farabeuf.
FIG. 281.

Mickulicz.
FIG. 282.

FIGS. 271 to 282.—Incisions used for Resection of the Condyle of the Lower Jaw, and available for the operation of interposing a strip of the temporal muscle between the floor of the glenoid cavity and the inferior maxilla (Huguier).

either hear or feel that some adhesions have given way. The best way of carrying out the procedure is to draw the arm away from the side gently, then to flex the forearm on the arm, and perform rather rapid movements of rotation. This suffices to break down many adhesions. Now that the joint is more free, the arm may be brought first forward and then backward; and if there is no resistance to these movements, the arm may be raised, and finally circumducted. In all cases the surgeon's left hand should be kept in the axilla, on the head of the humerus, so as to appreciate its

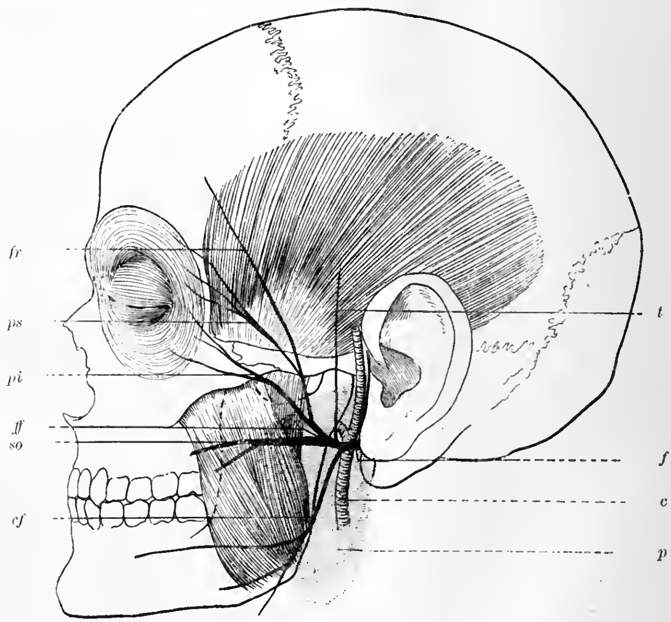


FIG. 283.—To show the anatomical relationships of the Temporo-Maxillary Articulation: *f*, trunk of the facial nerve; *ff*, temporo-facial nerve; *t*, temporal branch; *fr*, frontal branches; *ps*, branches to upper lid; *pi*, branches to lower lid; *so*, infra-orbital branches; *cf*, cervico-facial branches of facial nerve; *p*, parotid gland; *c*, external carotid artery (Huguier).

position, and see if it follows the movements of the shaft. Before full and free movements can be obtained, it may be that the patient will require an anæsthetic on several occasions. In the intervals between the operations, bathing with hot water or the application of hot air or radiant heat, massage, the use of the faradic current, and persevering efforts on the patient's part, are essential. Restoration of movement eventually follows, although it is sometimes much delayed.

When a fracture has extended into the joint from the scapula or from the humerus, the degree of ankylosis will be greater; but, provided there is no bony locking or nerve injury, careful and thorough treatment will restore the use of the joint.

Far different are those cases where there is a fracture of the surgical or anatomical neck of the humerus, and the head of the bone is dislocated. Formidable as these cases appear at the time of accident, yet, even if they are left alone, the patient secures a

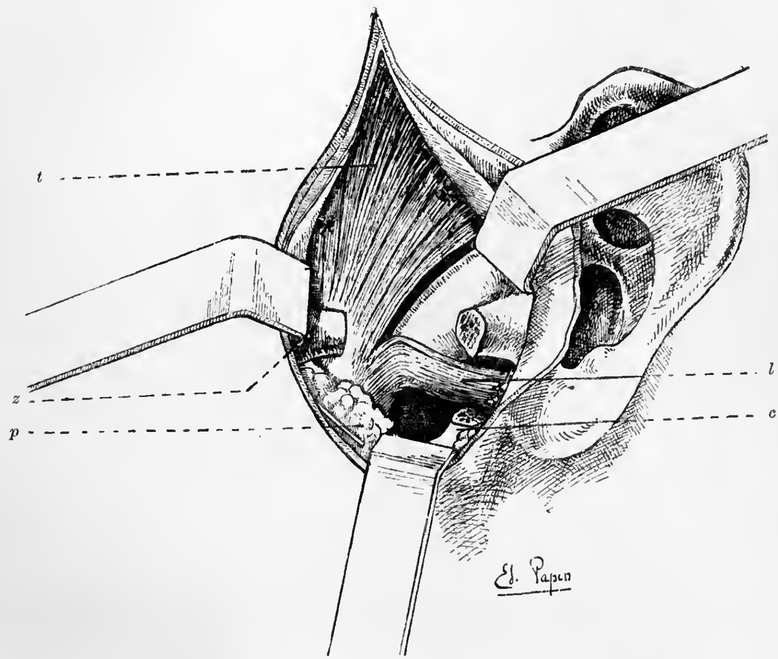


FIG. 284.—To illustrate the interposition of a slip of the Temporal Muscle to form a Ne-arthrosis for the Inferior Maxilla: *t*, temporal muscle; *l*, transferred slip of temporal muscle; *z*, zygoma; *c*, section of sawn neck of condyle; *p*, parotid gland (Huguier).

moderately useful arm. The question of the immediate treatment of these cases is one fraught with the utmost difficulty. So great is the effusion of blood at the time of injury that recognition of the nature of the lesion is often impossible unless X-rays be at hand. Even when the state of the parts has been diagnosed, doubt may arise as to what should be done, and this is largely dependent upon the condition of the circulation. If the main vessel is pressed upon, as evidenced by the absence of the radial pulse, then one of two courses is open: either to adjust the limb so that the pressure on the vessels is removed, bearing in mind, however, the possibility of tearing the brachial artery by the sharp upper extremity of the lower fragment of the humerus; or, the judicious surgeon will place before the patient all the risks of leaving the parts as they are, and in the fullest manner possible all the risks of operation, then fortifying himself with the opinion of a colleague, he will leave the patient to decide which course should be taken. An operation at this time is extremely formidable and requires great skill and dexterity, whilst the results are problematical, except so far as the relief of pressure on the blood-vessels is concerned. In five cases

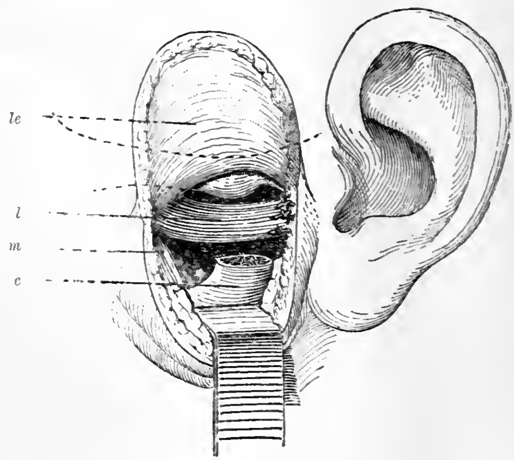


FIG. 285.—The completion of the Interposition of a strip of the Temporal Muscle: *m*, masseter; *l*, interposed strip of temporal muscle; *c*, section of decapitated neck of condyle; *le*, cutaneous flaps (Huguier).

which have come under my notice some weeks after the injury, where the dislocation has not been reduced or the fracture set, I have cut down to the parts from the outer side, removed the head of the bone, and cut off any projecting fragments from the humerus. The result has been fairly successful, as the movements at the shoulder-joint were largely restored.

Bony Ankylosis of the Shoulder-Joint.—If it be in good position it is often desirable to leave it alone. If in bad position, an osteotomy, linear or wedge-shaped, may be undertaken. The formation of a ne-arthrosis in this situation is not so important a matter as in the case of the hip or elbow, or the temporo-maxillary articulation.

Ankylosis of the Elbow.—The most common form of fibrous ankylosis of this joint is the result of fractures into the joint. Much loss of movement subsequently may be obviated if the practice followed by H. O. Thomas and Robert Jones be carried out. By these surgeons the method of treatment has been reduced almost to a principle. It is this: in all doubtful[1] injuries of the elbow-joint, except fracture of the olecranon, supinate the forearm fully, acutely flex it, and place it in a sling, with the ball of the thumb touching the cheek on the opposite side. After ten to fourteen days the forearm may be lowered a little, and left so for two days. If at the end of that time the patient is able to flex the

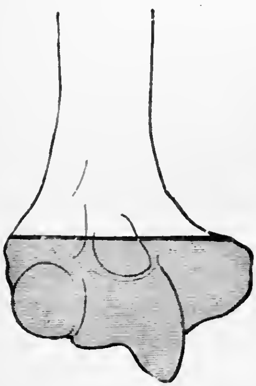


Fig. 286.

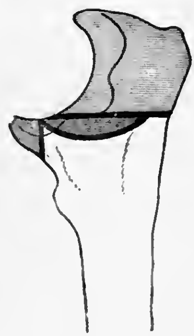


Fig. 287.

Figs. 286, 287.—Diagrams of the articular ends of the Humerus and Ulna, to illustrate the amount of bone which must be removed in the formation of a Ne-arthrosis of the Elbow (Huguier).

forearm to the original position, its angle of flexion may be diminished; but if not, the forearm must be put up in the first position, and then trial made again after a few days. In almost all cases it will be found that the forearm can be gradually dropped, and finally good movement is obtained.

Cases of tuberculous ankylosis of the elbow-joint, provided that the parts are in good position, should be left alone.

In bony ankylosis of the elbow, subsequent to fracture or to one of the forms of synostosing arthritis, the patient may require

[1] The word "doubtful" is applied to the pre-Röntgen ray era rather than now, when we can verify our diagnosis by these means. Nevertheless the principle of treatment holds good now as well as formerly, and its soundness is demonstrated time after time by X-ray photographs.

treatment because of the bad position, or it may be desirable to attempt to obtain a new joint. The forms of operation which may be done are linear or cuneiform osteotomy, or the formation of a ne-arthrosis. The steps of the latter operation are as follows:—

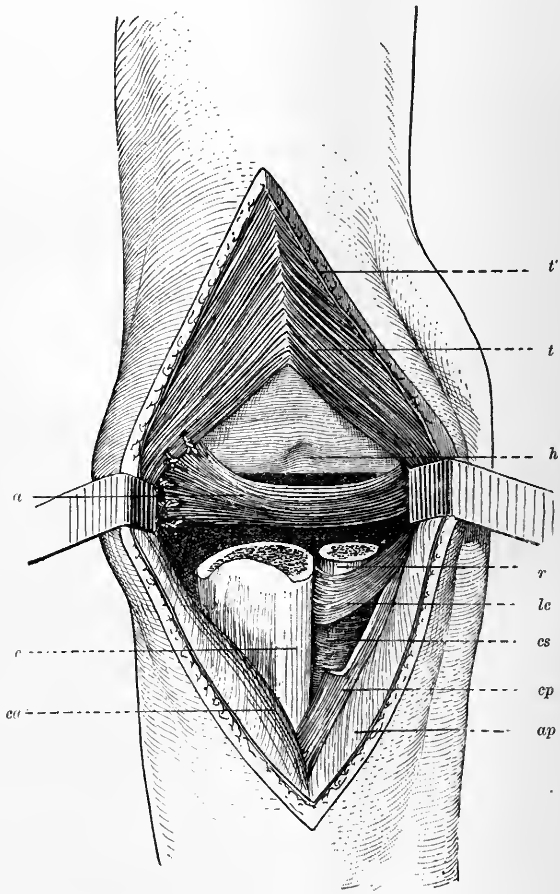


FIG. 288.—Interposition of muscular strips between the Humerus and Bones of the Forearm: *a*, anconeus, interposed between the humerus, *h*, and bones of the forearm; *r*, radius; *c*, ulna; *lc*, slip of ext. carp. rad. longior, *cp*, interposed between radius and ulna; *t*, triceps and its tendon *t'*; *ca*, ext. comm. digitorum; *cs*, supinator brevis; *ap*, deep fascia of posterior surface of elbow-joint (Huguier).

A longitudinal incision is made on the posterior surface of the joint; the periosteum is carefully dissected away and removed from those parts of the bone which formerly corresponded with the

PLATE XXIV.

Radiogram of a Ne-arthrosis of the Elbow (Huguier). The operation was performed upon a child aged 8 years by M. Albarran for ankylosis following injury, and a strip from the triceps interposed. The skiagram was taken five-and-a-half months after the operation. Active flexion was possible to 65° and active extension to 115°, pronation and supination were normal.

To face page 534.

articulation, the line of ankylosis is broken through, the ends of the bones are sawn off well above their former articular surfaces (Fig. 286, 287), a gap of at least $1\frac{1}{2}$ inches being made between the ends in an adult, and a piece of muscle is interposed. Berger and the author have used a strip from the anconeus (Fig. 288), Delbet a portion of the brachialis anticus (Fig. 289), and Quénu has grafted part of the aponeurosis of the triceps.

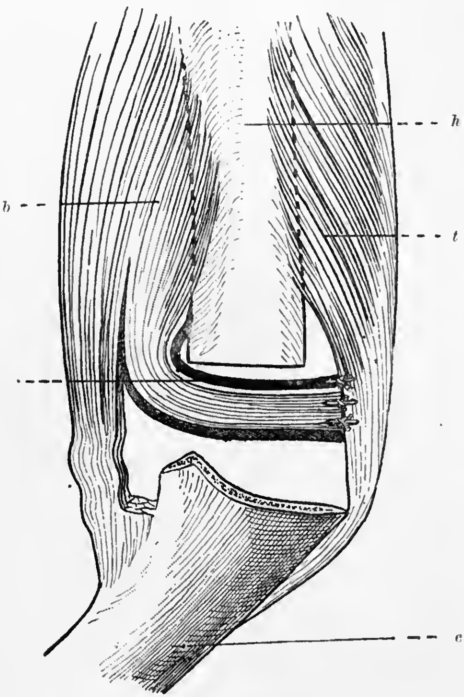


Fig. 289.—Interposition of a strip of the Brachialis Anticus in the formation of a Nearthrosis of the Elbow: *h*, humerus; *c*, ulna; *l*, anterior ligament of elbow-joint twined in between the bone-ends, and reinforced by a strip from the brachialis anticus, *b*; *t*, triceps (Hugnier).

After the operation, movement should be begun in twelve or fifteen days. The results are very satisfactory (Plate XXIV.).

Ankylosis of the Wrist.—Provided that the joint is in the mid-position, whether the form present is fibrous or bony, and particularly if it be non-tuberculous, it is best to leave it alone, unless the patient is insistent upon securing a more mobile hand. Then, after the risks have been duly explained to him, exsection may be undertaken. This procedure is certainly justified in bony ankylosis in bad positions.

Ankylosis of the Hip.—This may be fibrous—unsound or sound—or bony. Of the fibrous variety the tuberculous is the most

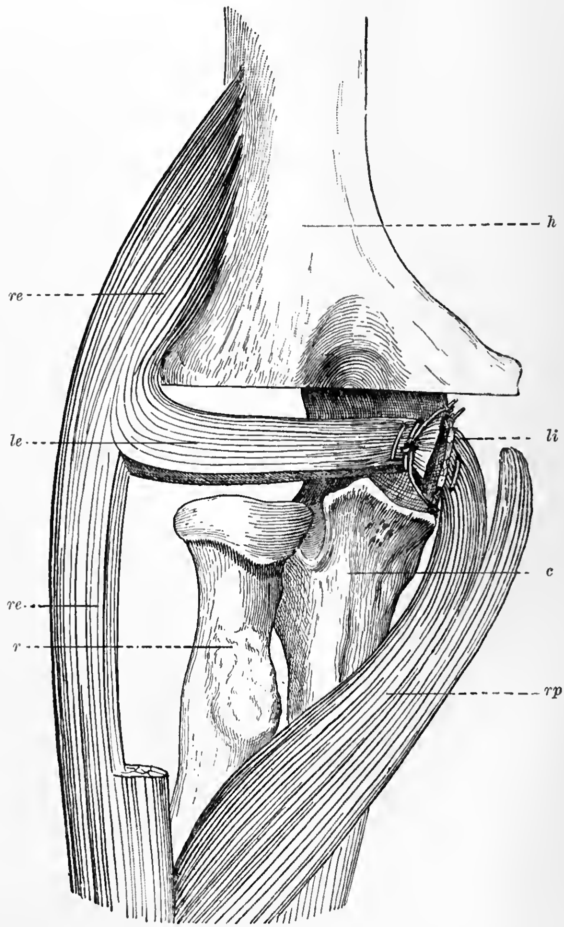


FIG. 290.—Ne-arthrosis of the Elbow by using conjoined strips of the Supinator Longus and the Pronator Radii Teres: *h*, humerus; *c*, ulna; *r*, radius; *re*, supinator longus, and *le*, strip derived from it; *li*, strip derived from pronator radii teres, *rp* (Huguier).

common. In the unsound form, very great improvement of the position of the parts can be obtained by weight-extension on an inclined plane after the manner of Howard Marsh (Figs. 151, 152). Some surgeons advocate the reduction of the deformity, even before the morbid process has ceased, by means of repeated and gentle manipulation, and they state that there is little fear of setting up fresh trouble. This view has not met with general acceptance. When a hip has recovered, and is in good position, no attempt should be made to secure movement. But where flexion, adduction, or internal rotation exist after the complete subsidence of the disease, and provided that the mal-position fails to yield to splinting or weight-extension, gentle manipulative measures may be tried at intervals of a few weeks, the limb being kept upon a Thomas' splint during this period. The final position should be one of full extension and abduction, so that the apparent lengthening of the limb in the abducted position compensates for the real shortening when the foot of the unsound limb is placed by the side of its fellow in standing.

Bony Ankylosis of the Hip.—If this be in good position it is best left alone, unless the ankylosis be bilateral, or the patient desire the formation of a new joint, with full understanding of the risks of the operation. When flexion exists, it has been the custom to rectify it either by an Adams' or a Gant's operation, after division of the contracted tendons on the flexor aspect. Some surgeons elect to do one and some the other operation, but, personally, we prefer an oblique trochanteric osteotomy, because in many cases the neck has disappeared, and so a true Adams' operation is not feasible. The surfaces for union are wide and broad, and extension of the limb does not give rise to any awkward projection of bone, such as occurs in the lower part of Scarpa's triangle in a Gant's operation. With the object of overcoming the inconvenience arising from shortening in these cases, R. Jones places the limb after the operation in a position of abduction on a modified Thomas' splint, at an angle varying with the degree of shortening (Fig. 175, p. 277).

Formation of Ne-arthrosis of the Hip.—Rochet of Lyons performed the first operation in 1895, and interposed muscle. Nélaton operated in 1899, using part of the rectus femoris. When the femur is ankylosed to the acetabulum itself, it is advisable to make use of the rectus femoris, but if it is fixed posteriorly and superiorly, a portion of the glutei muscles is more convenient for transposition. The case of J. B. Murphy[1] is one of the most successful on record. He dug the head of the femur out of the acetabulum, and lined that cavity with a flap of fascia lata. A

[1] *Op. sup. cit.*

year after the operation there was complete function of the joint and normal movement.[1]

Ankylosis of the Knee.—If of the fibrous variety, and without flexion deformity, we are of opinion that such cases are best left alone, although, under certain conditions, attempts to regain some movement in the direction of flexion have been successful.[2] If there is flexion deformity, and it is quite clear that all tuberculous disease has subsided, the contracted tendons and bands of fascia on the

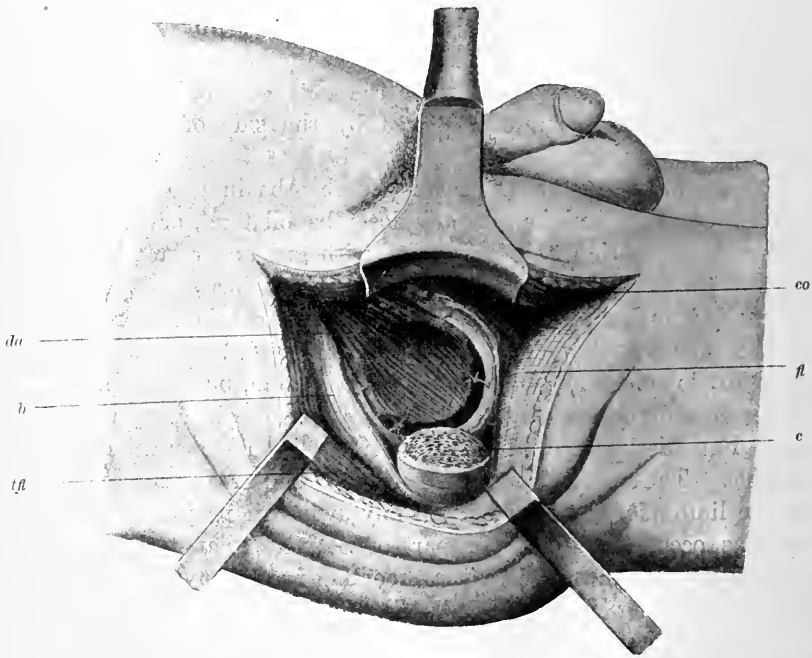


FIG. 291.—Arthroplasty (Ne-arthrosis of the Hip): *da*, slip of rectus femoris detached and then fixed so as to cover floor of acetabulum; *tfl.* tensor vaginæ femoris; *c*, neck of femur; *b*, external part of capsular ligament (Huguier).

posterior surface should be freely divided, and attempts made to straighten the limb. An important point in the procedure is that it should be only partial at one sitting, several sittings sometimes being necessary to obtain full extension. When the limb is straight,

[1] For the details of this operation see *Practitioner*, Feb. 1907; *Orthopædic Surgery*, by A. H. Tubby, p. 259; and further, Huguier's Thesis may be consulted. Robert Jones has introduced a promising modification (Figs. 292, 293) of the Murphy operation (*Brit. Med. Jour.*, 1909, vol. ii. p. 4).

[2] See *Med. Ann.*, 1900, p. 293.

it should be raised and fixed until all signs of inflammatory reaction are past. If an attempt is made to reduce completely a flexion deformity of any considerable extent at one sitting, fracture of the thigh, rupture of the popliteal vessels, or gangrene of the limb may ensue. In those cases where the subluxation is extreme, the angle of flexion great, and the fixation firm, the procedure advised in the case of bony ankylosis must be adopted.

Bony Ankylosis of the Knee.—If the flexion be acute, and osteotomy is not advisable, because it may result in the lower

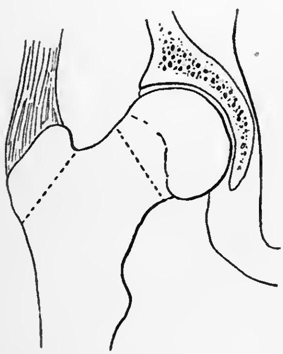


FIG. 292.

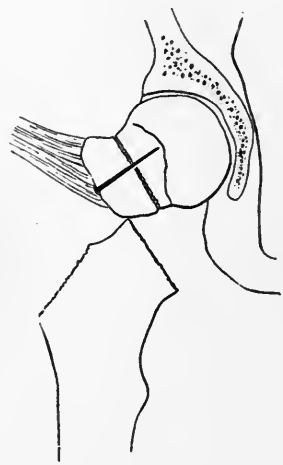


FIG. 293.

To illustrate Robert Jones' operation of Ne-arthrosis of the Hip. In Fig. 292 the oblique line of incision of the neck of the femur is seen, also the line of separation through the base of the great trochanter. In Fig. 293 the great trochanter with the muscles attached is pegged on to the raw surface of the proximal portion of the neck of the femur (from Binnie's *Operative Surgery*).

fragment of the femur protruding into the popliteal space, the best operation is a cuneiform resection. A flap is turned up over the site of the joint, and a V-shaped wedge is removed, taking care that the apex of the V[1] does not reach the posterior aspect of the bone by a good half inch (Fig. 153, p. 310). The fracture is completed by forcible flexion. The posterior sharp ends are then trimmed, and the limb fully extended. This method makes the operation perfectly safe so far as the artery and vein are concerned. Care must be taken in the removal of the wedges not to injure the epiphysial lines. Prolonged fixation of the limb is required after

[1] See Fig. 7, *Med. Annual*, 1900, p. 295.

the operation. J. B. Murphy has performed arthroplasty for both fibrous and bony ankylosis. He separates the femur and the tibia, and the patella from both these bones; and then he inserts flaps of fascia lata, and fixes them between the parts (Binnie, *Man. Oper. Surg.* 4th ed. vol. ii. p. 292). G. G. Davis has introduced a modification of Murphy's method. Lexer (*Arch. f. klin. Chir.* lxxxvi. 952) has transplanted an entire knee-joint.

Ankylosis of the Ankle calls for little comment. If fibrous and in false position, it may be rectified by manipulation, after subsidence of the disease. If it is false, or if bony union be present, excision of bone is readily performed.

CHAPTER II

OTHER AFFECTIONS OF THE BONES AND JOINTS (*Continued*)

Growing Pains—Infantile Scurvy—Hæmophilia of Joints—Osteomalacia (Mollities Ossium)—Osteogenesis Imperfecta (Osteo-psathyrosis) — Fragilitas Ossium—Achondroplasia (Chondro-dystrophia Fœtalis)—Acromegaly — Hypertrophic Pulmonary Osteo-Arthropathy—Fibro-Cystic Osteomyelitis—Osteitis Deformans (Paget's Disease)—Leontiasis Ossea—Neoplasms of Bone—Malignant Disease of the Spine and of the Hip—Actinomycosis of Bone—Hydatids of Bone.

Growing Pains

During the period of growth, children, particularly from the tenth to the fifteenth year, after fatigue, strain, or exposure, complain of pain, especially in the juxta-epiphysial region of the lower end of the femur. In many instances the pain is transient, and lasts for a few hours, and may be explained by the temporary hyperæmia of the part. In other cases the pains persist for days, and then a slight rise of temperature and some malaise are often noticed, and there is a little effusion into the neighbouring joint. It is probable that these cases are examples of the attenuated form of osteomyelitis, and are connected with transient sore throat. In other cases, where the affection persists for months, and is what the French call *Maladie de croissance,* there is a condition of hyperæmia of the epiphysis, perhaps analogous to that seen in rickets.

There is great difficulty in distinguishing the various forms of growing pains from acute rheumatism, chronic joint affections, and the early onset of tuberculosis.

Infantile Scurvy

Synonyms—*Scurvy Rickets, Barlow's Disease, The Möller-Barlow Disease.*

Formerly this disease, as it affects the bones, was called scurvy rickets, but from the researches of Sir Thomas Barlow[1] it is

[1] *Med. Chir. Transac.*, 1883, vol. lvi. p. 159. Also Bradshaw Lectures, R.C.P., *Lancet*, 1894, vol. ii. p. 1075.

quite clear that the disease is true scurvy, and that the rickets are co-incidental.

Ætiology.—There is no doubt that the disease arises from defective diet. Sterilised and boiled milk appears to be responsible for some cases, particularly if no fresh food is taken. The most severe forms are met with when the food is mainly farinaceous; and the bringing up of children on patent foods is often responsible for the onset of the disease. It occurs very seldom indeed in breast-fed infants, and when it does, the quality of milk supplied or the health of the mother is defective. English and American writers are in accord in believing the disease to be true scurvy, but Continental authors do not take the same view in its entirety, believing that its identity with adult scurvy is not yet proven.

Pathology.—In a fatal case, extravasations of blood are found in the deeper muscles, while the superficial ones are swollen and infiltrated with serum. The periosteum is thick and highly vascular, and is separated from the underlying bone by an extravasation of blood of varying extent. The hæmorrhage may be present at the epiphysis only, or extend up the shaft. In extreme cases the epiphysis is separated, and a mass of blood-clot intervenes between it and the diaphysis, so that spontaneous epiphysiolysis occurs. Blood is effused into the substance of the bone, more especially into the epiphysis. Rarefaction of the cancellous tissue is seen, especially in the ribs and at the juxta-epiphysial junctions. In addition to these changes, the ordinary rachitic signs are present in many cases. With the bone lesions, there are hæmorrhages beneath the mucous membranes and the skin, into the subdural space,[1] and into the viscera.

Symptoms and Signs.—The disorder occurs from the sixth to the eighteenth months, and it begins usually in ill-nourished infants, although it is occasionally seen in those apparently well nurtured. The characteristic signs are general tenderness on movement, the child being very fretful, and screaming when it is touched or lifted. The limbs are helpless, so that the child appears to be partially paralysed, and hence the term "pseudo-paralysis." The gums are swollen, red, and spongy. In a short time fluid swellings, which are neither red nor hot, appear on the limbs, and in close relation to the long bones. If dentition has not begun, the gums may appear to be healthy, and this may give rise to error in diagnosis.

Much information may be obtained from the collective investigations to be found in the *Transactions of the American Pediatric*

[1] Sutherland, *Ency. Med.* vol. xi. p. 62.

Society, 1898, vol. x. p. 5. It is shown there that the swellings appear mostly in the legs, in fact ten times as often as in the arms. The colour of the affected limb is usually natural, or, as we have seen it, of a yellow-white tint. Œdema can be demonstrated, and the thickening round the bones felt. In very severe cases the entire leg, or other part affected, is very much swollen, and the skin is white, shiny, and tightly stretched. It is in these cases that fracture and separation of the epiphysis occur. As a rule the joints escape. One not uncommon sign is exophthalmos, due to hæmorrhage beneath the periosteum of the orbital plates. Sir Thomas Barlow has described a curious condition of depression of the sternum, which is caused by separation of the costal cartilage from the ribs. Other signs of scurvy, such as hæmorrhage from the urinary passages, the nose, stomach, and bowel, are met with.

Prognosis.—In the mild cases, with appropriate treatment, the outlook is good and recovery is rapid, but in the severer forms, especially where extensive hæmorrhages have occurred, many children succumb.

Diagnosis.—The general tenderness and the enlargement of the epiphyses in the early stages are occasionally ascribed to rickets, but later on, when the typical bony swellings appear, the error is quickly rectified. The onset of the pseudo-paralysis and tenderness about the epiphyses have caused infantile scurvy to be mistaken for hereditary syphilis. We have also known acute periostitis and scurvy mistaken for each other, and have even seen incisions made down to the bone; when, the escape of a quantity of blood-clot has quickly revealed the mistake and the true nature of the disease.

Treatment.—The essence of treatment is to change the diet and to give fresh food, meaning by fresh that which has not undergone a preservative process. Thus fresh milk, raw meat juice, orange juice, grape or lemon juice, and potato cream are called for, but in giving raw meat juice the risk of tapeworm must be remembered. Potato cream consists of mixing the floury part of a steamed potato with milk until a creamy mixture is obtained (vol. ii. p. 402).

When the child begins to show signs of improvement, cod-liver oil and iron are useful.

During the acute stage of the disease the child should be carried about on a pillow, and great care taken not to twist the limbs or move them abruptly.[1]

[1] For literature up to 1902 see *Ency. Med.* vol. xi. p. 62, and after that see *Index Medicus* for 1903-1910.

Hæmophilia of Joints

In people who "bleed," chronic effusions occur from time to time into or about the joints, and these conditions are most often seen in children and young adults. A single hæmorrhage is often absorbed and leaves little trace behind it, but with repeated hæmorrhages definite changes occur. The synovial membrane becomes thickened and polypoid, and is stained reddish-brown. As a result of temporary deprivation of its nutrition, degeneration of cartilage and partial absorption occur. The capsule of the joint becomes altered, being stretched and weakened in one direction, and contracted in another. Adhesions form between the bone ends, and osteophytes are sometimes thrown out. When the interior of these joints is examined, it is always brown, being stained by the degenerated blood pigment.

Fig. 294.—Disease of the right knee-joint of six years' duration, due to Hæmophilia, showing swelling and flexion-deformity (Bradford and Lovett).

The onset of the affection is characterised by pain, then the joint rapidly becomes swollen and the capsule is fully distended. Reflex muscular irritation sets in; and when the knee is affected, which is the most usual site, the limb is flexed at that joint. As absorption occurs, these signs pass off, but recurrences are usual, either in the joint first affected or in others.

Diagnosis.—Such cases are usually mistaken either for tuberculosis or for syphilitic arthritis; yet, if attention is paid to the family and previous history of the case the error will be avoided.

Treatment.—Patients so afflicted should be on their guard to avoid injury or straining of the joint. When a joint has once been affected it is wise to protect it, as repeated attacks certainly impair the integrity of the joint. It may be permissible, for the purposes of diagnosis, to explore the joint with a very fine hypodermic needle; but the larger coarse needles, with the ordinary aspirator, should be avoided. Incisions into such joints, under the belief that they are tuberculous, have been followed by fatal consequences.

Of drugs, calcium chloride, beginning with doses of grains v., and increasing to grains xv., three times a day, has been useful, while during the attack, the administration of large doses of belladonna[1] by the mouth has apparently been of use in limiting the effusion.

Osteomalacia or Mollities Ossium

Osteomalacia or mollities ossium is a disease, possibly inflammatory in nature, possibly dependent upon a primary affection of the nerve-cells of the cord. It is characterised by absorption and disappearance of the lime salts, so that whilst the proportion of inorganic matter to organic matter in normal bone is about two to one, this relationship is reversed in osteomalacic bone.

The disease is one of adult life, and is far more common amongst females than males, and it is more or less endemic in Alpine and sub-Alpine districts. It occurs very often amongst peasant women who are badly nourished and have borne several children, and appears during prolonged lactation.

Pathology.—In addition to the disappearance of lime salts, which commences in the marrow and cancellous tissue, the medulla becomes congested, with an increase of lymphoid and fatty elements. Extension of the medullary cavity occurs, with great encroachment on the compact tissue, so that a very thin shell of the latter is left, which gradually bends or suddenly breaks. Spontaneous fractures are common, and often do not unite.

Symptoms.—At the beginning of the disease pain occurs in the spine and pelvis. It is constant in nature, and is worse after exertion. As to the causation of the pain, some authorities believe that it arises from pressure, others that it is of nerve origin. The next sign to be observed is a difficulty in walking, and the patient waddles. Then muscular weakness sets in, the knee-jerks are found to be increased, and ankle-clonus and muscular tremors are present. The pelvis is that portion of the osseous system first to be deformed, and becomes rostrated or beaked (Fig. 298). The softening process then extends to other parts, especially to the spine, which becomes

[1] Hesse, *Therap. der Gegenwart*, Sept. 1902; *Practitioner*, 1903, vol. lxx. p. 85.

kyphotic or scoliotic; to the ribs, which are compressed laterally, and to the long bones, which become bent, and are often spontaneously

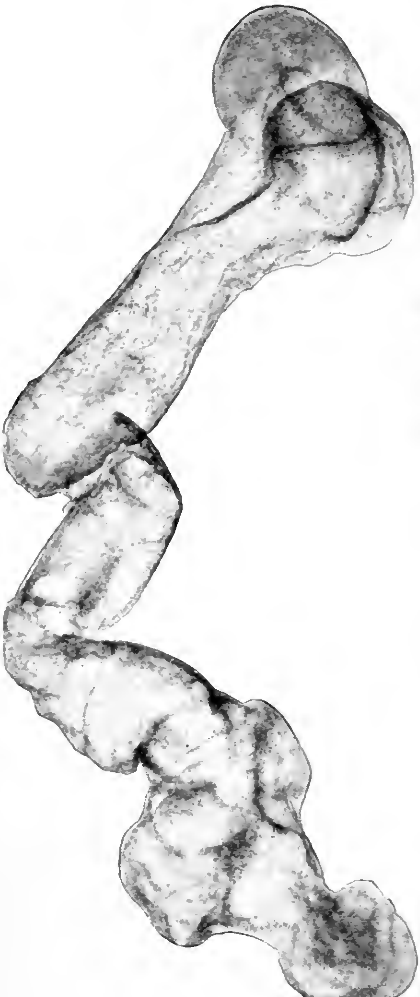


Fig. 295.—Skiagram of femur, distorted by Osteomalacia (Riedinger). There is general atrophy of the bony structure, the cancellous tissue is "alveolar." and the compact tissue is thin and paper-like.

Fig. 296.—Very severe general Deformity, especially affecting the left lower extremity, from Osteomalacia (Schuchardt).

fractured. Finally, unless adequately treated, the patient becomes hopelessly bedridden and dies.

Such is a description of the disease occurring in adults, and by some designated as the "puerperal" form. Another variety, however, may attack children and adults of any age. It cannot be traced to

FIG. 297.—Osteomalacic deformity of the right tibia (Schmieden).

any known cause, and it begins most often in the lower extremities or skull.

Prognosis.—The prognosis in the latter type is bad.

Treatment.—In many cases, distinct improvement and even recovery have been obtained by improvement of the hygienic surroundings, the use of salt baths, and the administration of cod-liver oil, phosphorus, and bone-marrow. In non-pregnant women double oöphorectomy has been performed with some measure of success. It is true that relapses have occurred after the operation, but such cases have been ultimately cured by persistence in the treatment previously mentioned.

FIG. 298.—Double Coxa Vara, due to Osteomalacia (Joachimsthal, after Albert).

Osteogenesis Imperfecta

Definition.—A rare and abnormal condition of the skeleton in which multiple fractures occur during intra-uterine life or in infancy and childhood.[1]

Nosology.—This affection was formerly classed as fœtal rickets,

[1] For a great deal of information on the nosology and literature and other points relating to this subject the author is indebted to a comprehensive article entitled "Osteogenesis Imperfecta," with the Clinical Report of a Case by R. W. Lovett, M.D.; Pathological Report by E. H. Nichols, M.D., *Brit. Med. Jour.* vol. ii., 1906, pp. 915-22.

but we now know that four distinct diseases in the new-born are included in the latter term. They are (*a*) true fœtal rickets beginning in intra-uterine life, the occurrence of this affection being disputed; (*b*) achondroplasia; (*c*) acromegaly; (*d*) osteogenesis imperfecta.

Synonyms which have been used for osteogenesis imperfecta are incorrect. Thus osteo-psathyrosis was applied by Lobstein in 1833 to fragility of the bones in general. "Infantile osteomalacia," "fragilitas ossium," "idiopathic osteo-psathyrosis," and "brittle bones" are so indefinite in their meanings as to be of little value.

Lovett and Nichols founded their observations on the disease on 123 cases.

Ætiology.—The only certain point is that the hereditary factor is a strong one. Dr. Griffiths of Cambridge places it at 15 per cent. Sometimes it involves a whole family, as instanced by Millard. The father was healthy, mother hysterical; ten children; seven daughters, six of whom had sustained one to four fractures; three sons, all of whom had one to four fractures; one grandchild on the female side, two fractures in four weeks.

Age.—In 23 cases, intra-uterine fractures are reported, mostly in still-born children, or in those dying during the first week. The earlier in life the fractures occur, the greater the probability is that they are due to this disorder; and, similarly, the greater is the number of subsequent fractures. If the first one takes place after four years of age, the probability is that the child is not suffering from osteogenesis imperfecta.

The Number of Fractures.—In one surprising case Chaussier found 113 fractures. In Blanchard's case 72 fractures took place between the ages of 2 months and 27 years. Other instances are recorded, thus: Mathieu noted 12 fractures up to the age of 16 months, and in another instance 36 fractures from 3 weeks to 17 years; Löver, 50 fractures from 18 months to 17 years; Griffiths, 17 fractures from 2 days to 2 years and 10 months; Schültze, 30 fractures from 9 months to 13 years. The individual rarely, if ever, attains middle life.

The fractures are not attended by much pain. They unite as a rule but slowly, and only a small amount of callus is thrown out, while the healing is frequently followed by deformity. Lovett and Nichols remark that "in cases of osteogenesis imperfecta, severe enough to result in intra-uterine fractures, the birth of the child is almost sure to result in a fresh fracture, so that in new-born children with the disease there is generally a combination of old fractures, united and partly united, and of loose recent fractures." The long bones are generally affected, the thigh most often, but the scapulæ, skull, vertebral column, and pelvis escape. Owing to the unnaturally softened condition of the bones, curvatures occur independently of fracture. Deformities also follow mal-union. Scoliosis is sometimes seen, and many of the children have a cretinoid appearance.

When the bones are examined by the X-rays, the cortex is thin

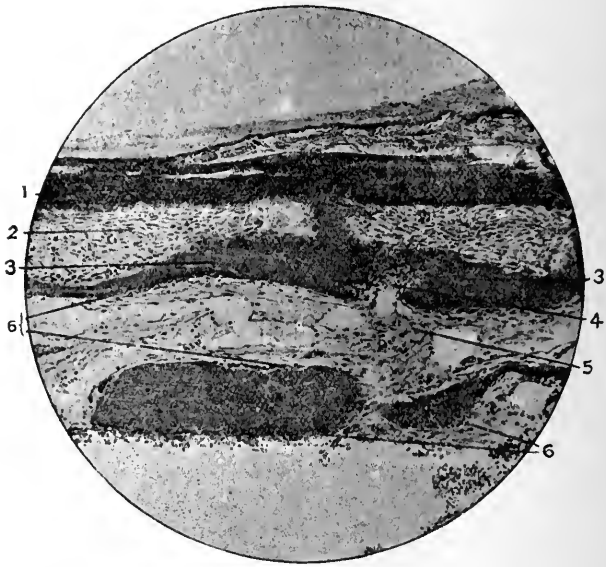


FIG. 299.—Section through Periosteum and Cortex of Rib. 1. Thickened fibrous periosteum. 2. Thickened layer of periosteal osteoblasts, largely spindle shaped. 3. Cortical bone plates of periosteal origin, forming cortex, not a continuous shell, but showing the perforations at 4. 5. Vascular œdematous connective tissue in cortical marrow spaces. The trabeculæ are beset with numerous osteoblasts, 6 (Lovett and Nichols).

and the medullary cavity is larger than usual, having trespassed upon the cortex. Lovett and Nichols give the pathological findings in the case of a male child, without hereditary history of fracture and not cretinoid, and with both thighs and both legs broken. The infant lived for 10 months, and during that time 10 partial or complete fractures were observed, all taking place before the age of 5 months. "At the pathological examination nothing wrong was observed with the internal organs, except small adrenals. To the naked eye the cortex of the bones was of nearly the usual thickness. The marrow was red, vascular, and very soft, and contained few trabeculæ. The periosteum was thickened at the points of fracture, but was otherwise normal. The epiphysial lines were curved, and not irregular as in rickets.

"Histologically, it was found that the process of ossification in this case differed from the normal in the following points: In normal ossification, the trabeculæ are formed by the deposit of bone by osteoblasts upon a scaffolding formed by calcified cartilage matrix. In the above case, however, no scaffolding was formed, but

FIG. 300.—Section of Spongy Bone, middle of shaft of femur. 1. Bone trabeculæ, showing imperfect lamination and imperfect bone corpuscles, without canaliculi and oval in shape, not stellate. 2. Osteoblasts on surface of trabeculæ. 3. Layer of œdematous fibrous tissue surrounding trabeculæ, course of fibres parallel to surface of trabeculæ. 4. Cellular normal marrow in marrow spaces (Lovett and Nichols).

the cartilage cells themselves were converted directly into bone, *i.e.* there was no intermediate stage of deposition, by the cartilage cells, of lime salts in the cartilage matrix. Also it was noted that the osteoblasts remained round instead of stellate, and that the bony trabeculæ showed imperfect or no lamination. The cortical layer differs from normal in having no Haversian canals, instead of them there are large marrow spaces; and the compact tissue, instead of being dense and laminated, was composed largely of non-laminated plates in which were oval cells. The marrow, especially near the epiphysial lines, had the appearance of œdematous and myxomatous connective tissue."

Treatment.—Nothing being known as to the causation of the disease, no preventive or curative treatment is possible. If a child is born with fractures, it should be handled with the utmost care, and be carried during the first few months on a pillow, and later be

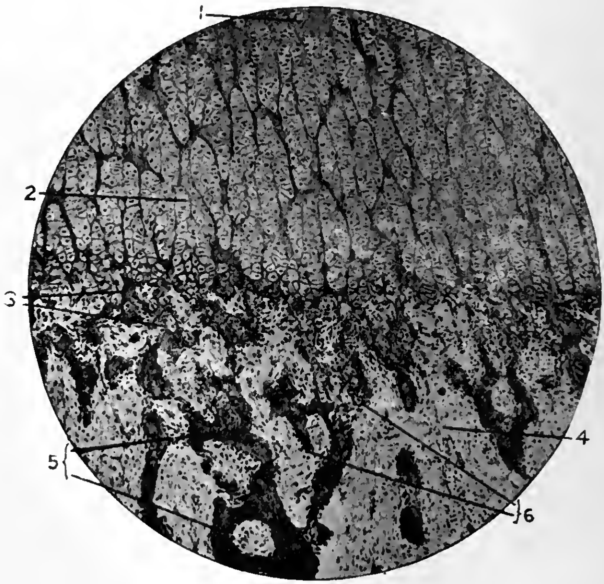


FIG. 301.—Epiphysial line of femur. 1. Zone of proliferative cartilage. 2. Zone of hypertrophic cartilage cells in columns, separated by strands of cartilaginous matrix. Line of provisional calcification not distinct. 3. Primary trabeculæ, composed largely of persisting cartilage cells, and beset by very few osteoblasts, except at some distance from the cartilage zone. 4. Œdematous myxomatous marrow. 5. Trabeculæ, with imperfect lamellæ. 6. Osteoblasts (Lovett and Nichols).

placed on an Adams' spinal tray. No unnecessary handling or sitting up is to be allowed, and the child is washed part by part, and is not put into a bath. When fractures occur they are treated on the usual lines.

Fragilitas Ossium

This term indicates not a disease, but a symptom met with in the course of many diseases such as osteomalacia, rickets, syphilis, scurvy, phosphorus poisoning, insanity, locomotor ataxy, inflammatory and malignant affections of bone.

Achondroplasia

Synonym—*Chondrodystrophia fœtalis.* (Kaufmann.)

Achondroplasia[1] is a disease occurring *in utero*, and is a disturbance of the normal process of ossification of the primary cartilage; atrophy of that structure occurs, and ossification takes place abnormally early. It commences apparently between the third and sixth months of intra-uterine life, and has almost ceased at birth. By some it has been described as fœtal rickets. However, in rhachitis the cartilages of the epiphyses are overgrown, and ossification is delayed, whereas in achondroplasia the epiphysial cartilages are atrophied, and they ossify at a rate altogether abnormal.

Fig. 302.—View of a child, affected by Achondroplasia (Bradford and Lovett).

Causation.—The only certain fact is that in some cases it is hereditary, and it occurs in families where sporadic cretinism and infantilism are seen. It is also remarkable that it occurs in animals, and dachshunds are achondroplasics. No definite relationship with any of the ductless glands has been established.

Course of the Disease.—It begins during the third month of fœtal life, and the process is probably over by the sixth month. Many of the severer cases probably die *in utero*, and only the slighter ones survive. When the child is born, it may be prematurely, it appears to have suffered from a very severe attack of rickets, and presents the following appearances: The head is of normal or of large

[1] For much of the information contained in this article the writer is indebted to the article "Achondroplasia," by Sir John Thompson, in the *Ency. Med.* vol. i. p. 55, and a notice of the literature on the subject is given there up to 1899. Further references will be found in Bradford and Lovett's *Orthopedic Surgery*, 3rd ed. p. 282.

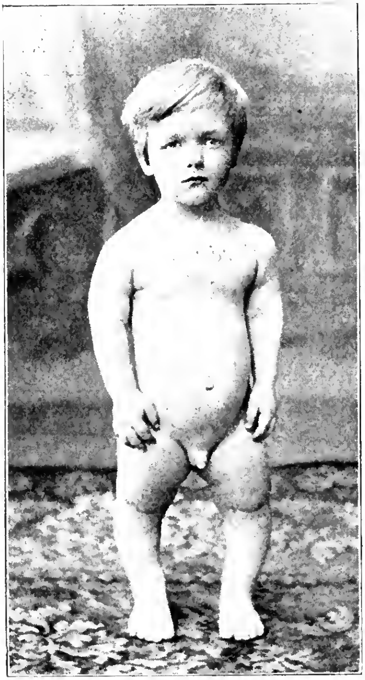


Fig. 303.

Fig. 304.

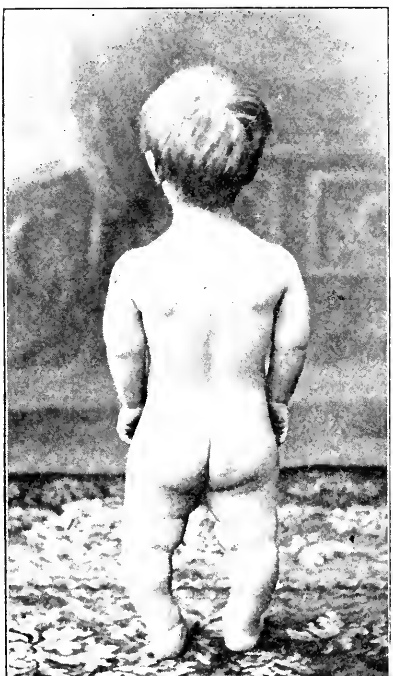


Fig. 305.

Fig. 306.

Four views of a child, under the author's observation, affected by Achondroplasia. In Fig. 306 note the widening of the cleft between the index and middle fingers.

size, the cranium being high and bulging. The bridge of the nose is absent, and the tongue often protrudes. The trunk is of the usual length, but is narrow from the shortness of the ribs and from the pelvic deformity. The striking points in the appearance are the extreme shortness of the limbs, which are not more than about half their natural length, the bones being thick, short, and curved, and the epiphyses large. The joints are often limited and restricted in movement. The hands exhibit a curious appearance, in that between the index and middle, or between the ring and middle fingers a considerable divergence exists, two fingers inclining towards the radial side and two towards the ulnar side of the hand in the latter case.

In adult life there is a striking disproportion between the body and limbs, and the patient is often dwarfed. In women the pelvis is extremely narrow, the conjugate diameter sometimes not being more than two and a half inches; so that, if pregnancy occurs, Cæsarean section has to be performed, as happened in a case brought to our notice by Dr. T. W. Eden.

Diagnosis.—In infancy, achondroplasia should be distinguished from cretinism. Patients suffering from the latter disease do not at that time show much disproportion between the limbs and body. In adult life the achondroplasic shows no rickety distortion in the spine, thorax, and head, and all the four limbs are equally shortened, while the hands still exhibit the peculiar divergence of the fingers.

Achondroplasics can be distinguished from adult cretins by their normal temperature, the absence of skin changes, their muscular and intellectual vigour, and the natural development of their sexual organs.

Treatment.—No treatment has been found to be of any avail.

Acromegaly

This disease was first described by Pachyakray and von Recklinghausen. It is characterised by hypertrophy of the hands and feet, of the head and the face, and by a tumour of the pituitary body. Marie distinguishes two types of acromegaly, the *type en large*, in which there is an increase in the breadth of the fingers and the hands, and the *type en long*, in which their length is exaggerated.

Ætiology.—In most cases no definite cause can be assigned. It has been hereditary in some cases, and acute infectious disease, fright, shock, rheumatism, and syphilis have preceded the disease in others. The age of onset is very variable, occurring between the twentieth and the fiftieth year, and it is more frequently found in women than in men.

Symptoms. — The appearance of the patient is very characteristic. The head is enlarged, both in the bony and soft parts, and the occipital protuberance is very prominent. The face is overgrown, with prominent orbital and zygomatic arches; the nose is big, and its septum is much wider than normal. The lower jaw is prognathous, and is a striking feature of a very ugly face. The lower lip is prominent, and the ears are large. The hands, whilst they increase in size, retain their natural outlines. The fingers are broad and unwieldy, and the nails small. The feet also are ponderous, and the toes broad, especially the big toe. The hypertrophy in the parts mentioned is chiefly in the soft parts, although the bones are somewhat thickened, and occasionally a few osteophytes are formed. The vertebral column often shows a definite kyphosis in the cervical region, and the clavicles are broad and prominent; whilst the lower part of the sternum is projected forwards, and the chest is increased in the antero-posterior direction, and decreased in the lateral. The sternum itself is thickened, widened, and elongated, and on its anterior surface there is a series of grooves. The ribs are much increased in bulk, so that their edges are almost in contact. The result is that respiration is often impeded.

Among other symptoms we notice thickening of the skin and subcutaneous tissues, a harsh husky voice, dyspnœa, dilatation and weakness of the heart, enlargement of the liver and spleen. Glycosuria, occasional or persistent, occurs, and death from diabetic coma is not infrequent. Functional nervous symptoms are not uncommon, especially headaches of a very severe and persistent nature. The optic changes are well marked. Hemianopsia is not unusual, and optic atrophy can be detected with the ophthalmoscope.

Prognosis.—The duration of the disease is from ten to twenty years or more. It commences insidiously, and the symptoms develop slowly, the condition sometimes remaining stationary for a time, and then lighting up again; and death takes place from exhaustion and dilatation of the heart. In some cases the disease is more acute, and then a sarcomatous tumour of the hypophysis cerebri has been found.

Pathology. — In the bones and cartilages the changes are hypertrophic, associated with vascularity of the medulla and hæmorrhage. The pituitary body is in some cases simply hypertrophied, and shows colloid degeneration or an adenomatous growth, whilst in other cases the tumour is a sarcoma or a glioma. From Furnivall's statistics [1] it seems that in all the fatal cases the pituitary gland was affected.

Diagnosis.—Careful distinction should be made between this disease and myxœdema, Paget's disease, and the diffuse hyperostosis occurring in leontiasis ossia.

Treatment.—So far no treatment has been successful, although after the administration of extract of pituitary body some cases show a temporary recession.

Hypertrophic Pulmonary Osteo-Arthropathy [2]

Although the term "pulmonary" is introduced into the nomenclature of this disease, yet extended investigations show that causes, other than those arising in the lung, produce the typical symptoms of this disorder. A most complete description is given by Dr. Symes Thompson,[3] and we have drawn largely upon his writings on the subject.

This form of osteo-arthropathy is a chronic symmetrical disease of the bones, joints, and soft parts, affecting chiefly the distal segments of the extremities. It appears that Bamberger in 1889, and quite independently of him, Marie in 1890, were the first to describe the disease. The description of the latter writer has been found to be so satisfactory that some authors call the affection Marie's disease; and this has the advantage, not only of conciseness, but also of excluding the term "pulmonary," which is not sufficiently comprehensive. Many other titles have been used, yet to mention them will tend to cause confusion.

Dr. Symes Thompson's paper is based upon 100 cases, and the careful analysis, which he gives, renders his remarks authoritative.

Ætiologically the affection is much more common in males than in females. Thus 86 per cent of the cases were in males, and 14 per cent in females, and the condition is usually seen in middle age. It generally occurs in association with suppuration in the thorax, it is seen in congenital heart disease and syphilis, and is met with in

[1] *Transac. of Pathol. Society*, 1898.

[2] Cf. Symes Thompson's article, *Med. Chir. Transac.* vol. lxxxvii., an exhaustive and critical resumé of the subject.

[3] *Med. Chir. Transac.* vol. lxxxvii. pp. 85 *et seq.* A valuable bibliography is found on pp. 120-24 of that volume of the *Transactions*.

association with psoas abscess and persistent diarrhœa. In the majority of cases, however, some disease of the lung is present. The function of the lungs is to eliminate the volatile toxins in the expired air; and, if for any reason the full activity of these organs be retarded, toxins accumulate in the blood, and give rise to changes typical of the disease. So that, while suppurative foci

FIG. 307.—Hypertrophic Pulmonary Osteo-Arthropathy, affecting the radius and ulna (Thorburn and Westmacott).

FIG. 308.—The Bones of the hand, affected by the same disease (Thorburn and Westmacott).

elsewhere in the body may produce toxins, yet so long as the lungs are healthy the disease does not make its appearance.

Pathology.—The changes in the bones are the following: Hyperplastic periostitis takes place, which results in the formation of new bone beneath the periosteum; and sclerosis of the cancellous tissue occurs, giving rise to compact new bone, which narrows the medullary canals. The arthritic changes are evidenced clinically by intermittent passive effusion, either with or without inflammatory signs, and the articular cartilages are often eroded. The soft parts around the joint undergo thickening, which is, however, never very great, and does not affect the skin. Clubbing of the fingers and toes is nearly always present, and precedes the bone and joint changes. The nails are large, broad, and brittle, and so incurved that the

FIG. 309.—A view of the Lower Extremities of a patient. The knees and bones of the legs are affected by Hypertrophic Pulmonary Osteo-Arthropathy (Thorburn and Westmacott).

name "parrot-beaked clubbing" has been suggested. The ends of the digits are thickened, both transversely and antero-posteriorly, and even enlargement of the end of the nose has been described.

The onset is very insidious, and slight stiffness of the wrists and ankles is the first sign. It is succeeded by some swelling and discomfort in these joints, the swelling being often due to effusion.

Clinically two groups appear: (1) The arthropathic, in which the joint conditions predominate, and (2) the osteopathic, in which there is much tenderness of the bones involved, whilst the affection of the joints is fugitive. In other instances the arthropathic phase of the disease dies away, the osteopathic stage becomes pronounced, and then the segmental bones of the hands and feet show typical thickening and elongation. The striking point about the disease is its definite symmetry. Kyphosis is often associated with osteopathy, its origin is probably postural, and is due to the patient being propped up for a long period in bed. Scoliosis, when present, probably arises from the primary thoracic disease.

Whilst the hands and feet are mainly affected, the hip, shoulder, knee, elbow, ankle, and wrist joints, and even the skull bones, have been found sclerosed on post-mortem examination.

Of all the forms of lung diseases, bronchiectasis is the most prolific in giving rise to the train of symptoms.

Diagnosis.—The rarity of the disease is such that it has been mistaken for rheumatism, gout, and arthritis deformans. In the last, the typical creaking and the lipping of the joints are distinctive features. In neuropathic arthropathy we find increased mobility and evidences of nerve disorders. Tuberculous dactylitis is often asymmetrical, and presents very definite clinical signs. For a considerable time, osteo-arthropathy was confused with acromegaly, yet the latter disease is always a primary disorder. The central nervous symptoms common in acromegaly, such as headache, irritability, vomiting, visual changes, marked thickening of the skin, are absent in osteo-arthropathy. In acromegaly we find a definite facial aspect, while the fingers are not clubbed, but square, and the enlargement is of the nature of "gigantism."

Prognosis.—Unless the primary disease is arrested, the osteo-arthropathy steadily increases in severity; whilst the clubbing of the fingers disappears if the pulmonary affection is arrested, but absorption of new bone does not take place.

Treatment.—This must evidently be directed to the primary disease. If the joint symptoms become troublesome, salicylate of soda should be tried, and the parts may be painted with tincture of iodine or with the extract of belladonna.

ADDITIONAL REFERENCES TO THOSE GIVEN IN DR. SYMES THOMPSON'S ARTICLE (*Trans. Roy. Med. Chir. Soc.* vol. lxxxvii.)

RANVIER. Rev. de Méd., 1891, 30.
WHITMAN. Pediatrics, 1899, vi.; Nos. 4 and 5, with Bibliography.
JANEWAY. Amer. Jour. of Med. Sci., October 1902 (with Bibliography).

Fibro-Cystic Osteomyelitis

Synonym—*Von Recklinghausen's Disease*

This rare disease is seen in children and adolescents, and may affect one or more bones.

The chief changes appear in the marrow, the normal structure being replaced by vascular fibrous tissue, in which cysts[1] are often seen, hence the term "osteomyelitis fibrosa cystica." The cysts are epithelial-lined and contain a clear yellowish fluid. In the fibrous tissue giant cells, like those of a myeloid sarcoma, and occasionally cartilage cells are found; the cases, however, have not the same clinical history. The medullary cavity increases at the expense of the denser outer layer, so that the compact shell is much thinned and weakened, and therefore fractures readily occur.

As a rule, the disease gives rise to no symptoms until fracture happens, or the shaft becomes bent, or the compact shell enlarges and becomes fusiform. The surface is often irregular. From other bone-affections the diagnosis can be made by X-ray examination, when the cysts are clearly seen in the fibro-cystic form.

Treatment.—If one bone only is affected, the medullary cavity may be opened and scraped out. If many are involved, this course is not feasible, and the limbs are protected by poroplastic or leather splints, so as to avert fracture. If this takes place, union is long delayed, and the bone usually becomes curved and shortened.

Osteitis Deformans

This rare disease is also known as *Paget's Disease, Osteitis Chronica Deformans Hypertrophica, Paget'sche Krankheit.* It was first described by the late Sir James Paget[2] in 1877, and to his lucid account little has been added of late years. "The bones enlarge, soften, and those bearing weight become unnaturally curved and misshapen." It is chiefly the shafts of the long bones which are affected, and remarkable changes take place in the cranium and spine, although the bones of the face usually escape, thus distinguishing it from leontiasis ossia.

[1] Cf. an exhaustive article by Joseph C. Bloodgood, entitled "Benign Bone-Cysts, Ostitis Fibrosa, Giant-celled Sarcoma, and Bone Aneurism of the Long Bones, concluding that Conservative Treatment is justifiable," *Annals of Surgery*, vol. lii. No. 2, Aug. 1910, pp. 145-185.

[2] *Med. Chir. Transac.* vols. xl. lxv.

The first point the patient notices is that his stature is decreasing. Thus, a patient lost three inches in height in two years. The head also becomes larger, and the size of the hat is

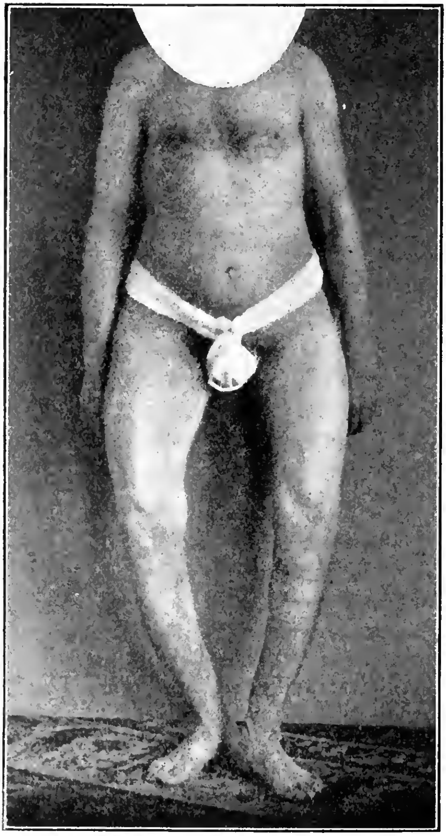


FIG. 310.

FIG. 311.

Osteitis Deformans (Paget's disease), in a male, aged 54 years. The first signs appeared seven years previously. The disease is marked in the cranium, clavicles, right ulna, left radius, pelvis, tibiæ, and fibulæ (R. B. Osgood).

increased from time to time. It appears, however, that the disease commences in the lower extremities before it affects the spine or cranium, although the change in the lower limbs escapes the patient's notice at first. In some instances the upper extremities and clavicles are affected.

Skiagram of a Leg affected by Osteitis Deformans, showing bowing and lamellar thickening of the tibia and fibula: also areas of rarefaction or true cavity formation with apparent periosteal overgrowth and true cortical increase: and coarse trubeculation with partial obliteration of the medullary cavity. Marked arterio-sclerosis existed (R. B. Osgood).

To face page 563.

The pathological process results in a thickening of the bones, which are at first soft, and therefore bend, but later become harder. The compact tissue is usually increased to as much as five or six times its normal thickness in most cases; in the minority of instances the cancellous tissue is hypertrophied. In fact, we find a combination of rarefying and formative osteitis. Rarefaction goes on in the interior of the bones, with formation of new compact tissue beneath the periosteum. In dried museum specimens the appearances are quite typical. The bones are heavier, thicker, and more curved than normal, and when dried, seem as if they had been lime-whitened, having a white coral-like appearance. Microscopically, the process is a chronic osteitis, as has been shown by Sir H. Butlin. It appears as if absorption and new formation were going on at the same time in the bones. The marrow and vascular spaces are increased in size, and the fat is changed into fibrous tissue. Howship's lacunæ appear in the bone, where it is becoming rarefied. The sub-periosteal deposit of new bone is at first soft and poor in lime salts, but when these are ultimately deposited, the new tissue is thick and sclerosed. It is a striking fact that a very considerable proportion of these cases, from one-half to two-thirds, succumb eventually to sarcomatous degeneration.

FIG. 312.—Section of skull from a case of Osteitis Deformans, showing enormous thickening (Alexis Thomson and Miles).

Ætiology.—It is a disease of adult life, and of people who are prematurely old. In the majority of cases arterial sclerosis is marked, and in some other cases signs of arthritis deformans are present. Of sixty-seven cases collected by Packard, Steele and Kirkbride,[1] 61 per cent were in males; and Osgood and Locke[2] found that in twenty-five cases, men were much more frequently attacked than women. These writers also found that the average age of onset in twenty-one cases was 43 to 44 years.

Formerly, two views were held: one that osteitis deformans is

[1] *Amer. Jour. of Med. Sci.*, November 1901.

[2] Quoted by Bradford and Lovett, *Orthopedic Surgery*, 3rd ed. p. 257.

a late manifestation of hereditary syphilis, syphilis hereditiva tarda, and the other that Paget's disease is due to chronic rheumatism, and, in fact, is nothing else. These ideas are no longer accepted; for radiography has shown them to be untenable. Another theory is that the disease is due to perverted trophic influences. In infantile paralysis, spastic paralysis of childhood, tabes, and syringomyelia, definite bony changes are met with. In many instances, too, of Paget's disease diffuse alterations have been found in the spinal cord.

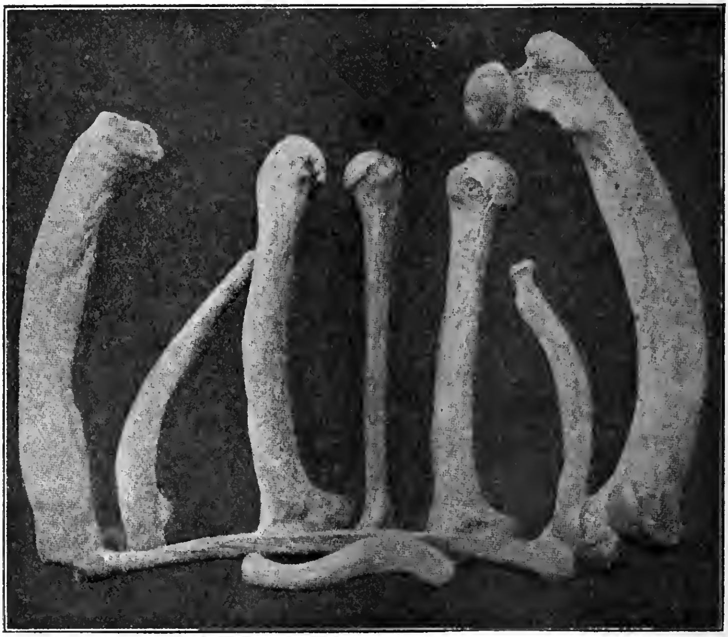


FIG. 313.—The Long Bones in Osteitis Deformans; *a* is a normal humerus for purposes of contrast.

However, it has not been possible to establish a definite relationship between the disease and these changes. During 1909 two fresh instances have been reported in the pages of the *Nouvelle Iconographie de la Salpêtrière*, one by M. Klippel and M. Pierre Weil, and the other by M. Pascarolo and M. Bertolotti.[1] The first of them was in a woman, aged 56 years, in whom the disease had made its appearance eleven years previously, and had slowly progressed without pain. In her, the characteristic features of marked overgrowth and thickening of the bones, with curving of the long bones

[1] *Lancet*, 13th November 1909, p. 1452.

and scoliosis of the vertebral column, were almost entirely confined to the right side of the body. The curious symptom of an increased surface temperature on the affected side was noted in her case, the difference between the two sides being no less than ·5° C.; this symptom has been described by one or two previous observers. There was no discolouration of the skin, and no evidence of local inflammation. The second case was that of a man, aged 53 years, with a history of fifteen years' duration. Here, the condition was more or less symmetrical and much more widespread, involving, as is usual, the bones of the cranium, thorax, and pelvis, and, of course, the long bones. The interesting feature of these two new observations is that the patients were suffering from obvious circulatory disturbances; the man was arterio-sclerotic, and the woman had mitral insufficiency and was slightly arterio-sclerotic. In a large proportion of cases of Paget's disease, arterio-sclerosis has been observed, and the view that the condition is somehow a result of vascular changes in the nutrient arteries of the bones has much to recommend it. There must, however, be another element in the causation of the disease which has hitherto escaped the eye of research: arterio-sclerosis is very common; Paget's disease is rare.

It is highly probable in our opinion that the disorder is of the perverted metabolic type, just as is atrophic arthritis deformans in so many instances. In the description of a case which we shall give presently, there is evidence to show that a marked improvement took place when the diet was changed from a partly carbohydrate to one almost entirely proteid.

But, why in one disorder perverted nutrition from excess of proteid food should cause atrophic changes in the articular ends, and why in another hypertrophic changes, mainly in the shafts, should arise from excess of carbohydrate diet, and the symptoms be relieved by a great increase of proteid food is beyond our comprehension. The facts, however, are worth noting. It is possible that in osteitis deformans, as may be the case in arthritis deformans, the toxic products of perverted metabolism influence the vaso-motor and trophic functions of the spinal cord, and that the lesions are therefore secondarily due to central nervous disturbances.

Symptoms.—The affection is usually preceded by pains in the limbs and stiffness in the back. Some patients suffer much from malaise. In nearly all the cases the onset is very gradual, and is not accompanied by any appreciable diminution of health. The patient's attention is drawn to his condition by the rapid decrease in stature, by his head becoming larger, and if he is of an observant turn of mind, he will notice that the bones of his legs are becoming curved and thickened. When the disease is fully established, the attitude of the patient is very characteristic. It has been graphically described as "simian." The patient stands with the legs bowed outward, the body bent forward at the hips, the spine curved backward, and in rare cases laterally as well. The shoulders are rounded, and the enlarged head drops on the chest. The chest is often flattened laterally. As the disease progresses, neuralgic pains are often felt, especially in the head, from pressure on the nerves as they pass through the foramina, and in the body and legs from constriction of the spinal nerve roots. The joints of the limbs as a rule escape, but ossification of the spinal ligaments takes place, so that in old standing cases the whole spinal column may be fused into one curved mass. It is noticeable that fractures rarely occur, and when they do, they readily unite. On account of extension of the disease from the spine to the ribs, ankylosis of the costo-vertebral articulations takes place, so that the movements of the ribs are less, and respiration becomes almost entirely diaphragmatic. The curvatures in the tibiæ and femora are quite unique owing to their occurrence in middle life.

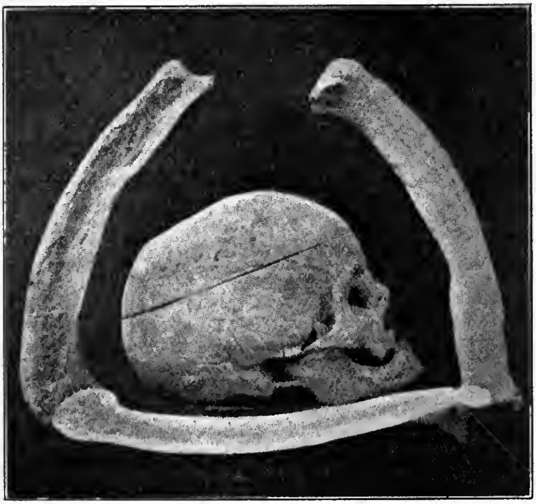


Fig. 314.—Skull and Long Bones, from a case of Osteitis Deformans (Bradford and Lovett).

On account of the affection of the spine, the disease has been mistaken for spondylitis deformans, yet the clinical picture of osteitis deformans, once it has developed, is too clear to be mistaken.

Prognosis.—The disease, so far as is known, is incurable, although it is one of great duration, some patients having suffered for nearly twenty years. Death usually takes place from intercurrent affections, more especially bronchitis and pneumonia, owing to the rigidity of the chest walls, and a considerable proportion of cases die from sarcoma of the bones.

Treatment.—It can be only palliative, but the feeling of strain in the back and the pains can be relieved by using a steel spinal support with axillary crutches. A sufferer from this disorder has furnished me with notes of his case from the beginning, and he kindly permits me to include his remarks here.

"A medical man æt. 54, a member of a long-lived and healthy family, addicted to mechanical hobbies, found six years ago that after working at his bench in a stooping position for two or three hours he had a difficulty in straightening himself, and a pain in the small of the back on trying to do so, such as is usual on such occasions in men advancing in life; but, whereas it commonly passes off in a few minutes, he found that it lasted longer with him, and in the course of a few months it lasted for half an hour, an hour, and longer, so that he used to lie down on his back to relieve the pain and straighten the spine. After some months he found the same pain and difficulty in straightening his spine began to occur after writing at his desk for an hour or two. This pain after stooping and difficulty in straightening himself increased very gradually, very insidiously, for several years. It did not of itself incapacitate him, except temporarily after stooping, but it gradually lasted longer and longer after each interval of stooping or sitting, and at the end of three or four years he gradually began to notice that his contemporaries were all growing. His friends all seemed to be becoming taller, and at the same time his family frequently admonished him to 'straighten up.' He had contracted a habit of stooping. At this time, about three and a half years after the onset of the symptoms, he found that after rising from the sitting position, if he had been sitting long, as, for instance, over a long dinner, he had a difficulty in starting to walk. He had to pause for a few moments, partly to straighten himself and partly to get his balance, before he could walk out of the room; and about the same time he began to feel a tightness of the hamstrings and subsequently of the muscles of the groins, which impeded him in straightening his legs. Up to this time he had not taken much notice of his symptoms, which for a long time he had attributed to the natural disability of advancing years, but now it became evident that he was the subject of disease; and, since his disability was widespread, a co-ordinated defect, apparently, of many muscles as well as, so it appeared, of the intervertebral cartilages, he inferred that it must be a defect of nutrition depending on the absence of some organic product, some ductless gland, or other tissue. In this belief he had recourse to bone-marrow (Armour's), and after a very few doses his symptoms were very much ameliorated. For some months the bone-marrow appeared to keep the malady in check; at any rate he became no worse, but after a time the pain and stiffness and inability to stoop re-appeared, and were no longer relieved by bone-marrow. Gradually, too, the pain became continuous.

It was felt not only after stooping, but in standing and walking, and the only position in which he was quite free from pain was when sitting or lying down. In August 1906 he had a sharp attack of influenza, not the first by any means that he had had while subject to the disease, but the first that was followed by a distinct exacerbation of the malady. After this the pain became more severe. It quite incapacitated him from stooping over his bench, and prevented him from writing for long together; for now, for the first time, he began to be in pain even when sitting, and was not altogether free when lying down.

"At this time he sought advice from Mr. Tubby, who found the lumbar curve of the spine obliterated and rigid, and the dorsal spine exaggerated in its curve and also rigid. Mr. Tubby also astonished the patient by asking how long he had been bandy-legged. Then for the first time he noticed a considerable curve forwards and outwards of the shaft of each tibia.

"In January 1907 he began to have pains in the long bones of the leg, and a feeling of weakness just above the ankle when walking, as if the bone was not strong enough to support his weight, and now also the arms began to be affected with the same stiffness that had previously attacked the back and legs. He found a difficulty in raising his hand to turn out the gas, in buttoning the back of his collar, and in other acts requiring much movement at the shoulder. The muscles of the arms partook of the wasting which affected those of the legs and trunk, and his physical weakness increased.

"The most distressing symptom now is the lack of bodily and mental energy. Always a very active man, used to long hours of work and strenuous recreation, he now finds the prospect of work distasteful, and, when he compels himself to undertake a task, he is soon so tired that he has to relinquish it and go and lie down. Formerly a good pedestrian, with a capacity of walking 20, 30, and 40 miles a day, he now has a difficulty in covering a mile, and is then much exhausted. For two or three days, after driving a motor car for three or four hours, he is incapable of exertion, and lies about in a state of exhaustion, listlessness, and semi-somnolence.

"The pain is not severe, but it is now almost continuous. He finds it present when he wakes in the morning, and it is present more or less all day. It is easiest when reclining, and worst after stooping. It is chiefly in the back, sometimes in the loins, sometimes between the shoulders. It has been concentrated in one spot under the left shoulder-blade. Lately, as already noted, there has been pain in the lower part of the tibia. A curious symptom is that when he wakes from sleep he always finds his head over-extended, so that the chin is in a line with the chest, and the occiput is down on the shoulders. He has lost three and a half inches in height.

"Another curious feature in the case is that, although he is no enthusiast for therapeutics, and has no great hope of relief from drugs, every time he tries a new drug there is a temporary and decided improvement. The amelioration that followed the use of bone-marrow has already been mentioned. Similar improvement followed the first few doses of thymus gland. It is not only that the pain is relieved, but the attitude is more upright, and the capacity for work increased. About this there is no manner of doubt. The same thing occurred, but in much less degree, after first taking cod-liver oil. Phosphorus appeared to have no effect, but there was some improvement for a few days on calcium lactate.

"Among other evidences of disease of the bones is increase in the size of the head. For the last three years, each hat that has been made for him has had to be larger than the last, and hats that he used to wear with comfort five or six years ago are now ludicrously small for him, and rest on his head by their edges only.

"Several years before the symptoms began, he had his first attack of gout, and then, being rather corpulent, he greatly diminished his diet in quantity, and has ever since restricted the amount of meat, taking it but once a day. He has always been a hearty and sufficient eater, however. He has had perhaps six or seven attacks of gout, no syphilis, there is no phthisis in the family, has always been a water-drinker, has lived a very healthy life, much in the open air, and has needed and taken eight hours' sleep out of the twenty-four. He has smoked a good deal.

"There has been no rise of temperature, no headache, but lately an occasional bursting feeling in the head, lasting a few hours. He had rickets in childhood, but they left no trace of deformity.

"Since this report, the disease has progressed much more slowly, and in some ways the patient has improved, having recovered all his mental and some of his bodily energy. This improvement he attributes entirely and undoubtedly to the adoption of a diet rich in proteid, and very sparing in carbohydrates. He has suffered many things of many physicians, and adopted many modes of treatment, but has not persevered long with them as they seemed entirely without effect. The pain in the back has almost entirely disappeared, and the deformity of the bones has scarcely increased at all. He attributes the whole malady entirely to error in diet—lack of protein mainly, but partly excess of starch. Eating potatoes never fails to produce a return of pain. He is much crippled bodily, able to walk but a very short distance, and soon fatigued, but his mental powers have never been more active.

"There is a great deal of crackling in the joints in movement, as if the cartilages had disappeared."

We are exceedingly grateful to the writer for this account of his case, and the fact that it is written by one trained and skilled in observation of details makes it all the more valuable. The hint as to the effect of change of diet, with great increase in proteids, is a useful one.

Leontiasis Ossea

Synonym—*Megalocephaly*.[1] This disease was first recognised by Virchow, and in its pure form affects the facial bones, although a variety of it is described as appearing in the cranial bones as well.

No definite cause is known. Unlike osteitis deformans, it is a disease beginning in early life, from the tenth to the thirtieth year. It progresses very slowly, and may last for twenty or thirty years.

The pathological condition is one of hyperostosis. Masses or bosses, composed either of cancellous or compact tissue, are formed, whilst the bone around often shows a diffuse hypertrophy. The maxillæ, and less frequently the nasal and frontal bones, are affected, so that the cavities of the orbit, the mouth, the nose, and the accessory sinuses are gradually obliterated, and great pain is experienced from pressure on the cranial nerves. The bony thickenings are as a rule symmetrical; although at first the excessive development is noticeable on one side of the upper or the lower jaw, which very slowly enlarges, and is sometimes mistaken for sarcoma or actinomycosis. The further symptoms vary according to the order of involvement of the cavities, and the patient's life is rendered miserable by exophthalmos, epiphora, and interference with the nasal respiration and mastication.

The most striking point about these patients is their facial aspect. They gradually acquire a truly lion-like appearance. We have met with three cases, one in the Throat Clinic in Berlin and two at Westminster Hospital, and have been able to recognise them at once by their characteristic aspect. In the last stages of the disease the patients are blind from exophthalmos, deaf, and suffer intolerable pain, due to pressure on the cranial nerves.

Such are the signs and symptoms of the localised form of leontiasis ossia.

In the diffuse form, which is extremely rare, an unequal involvement of the bones occurs. The cranial bones become large and heavy; although unequally affected, they are all involved in time. Their surface is uneven, but there are no large exostoses. In course of time, the disease extends to the bones of the face in some cases. We have once seen this form of the disease affecting

[1] Horsley, *Practitioner*, 1895, New Series, vol. ii. p. 12; Sternberg, *Nothnagel Spec. Path. u. Therap.* Bd. vii. Teil ii. Abteil 2, 1899; Stephenson, *B.M.J.*, 1900, vol. i. 1230.

the frontal bones in a woman of thirty, in whom we made an unsuccessful attempt to remove part of the thickening of the bones on account of the deformity produced.

Death of the patient ensues after several years, either from cerebral pressure, marasmus, or some other disease.

Diagnosis.—The patient's appearance and the gradual obliteration of the facial cavities are the most important distinguishing signs. Care should be taken to distinguish it from syphilis, sarcoma, acromegaly, and osteitis deformans.

Treatment.—This is only applicable when localised bony masses can be removed, or when it is possible to relieve pressure on nerves in accessible places.

Actinomycosis

Actinomycosis is a condition caused by invasion of the tissues by the streptothrix actinomycotica or ray-fungus, which is usually found in those whose occupation brings them in contact with grain and straw. A common instance is that of an ostler, who habitually has a wisp of straw in his mouth. Here the channel of entrance is probably between the gums and teeth; in other cases the disease appears primarily in the respiratory or gastro-intestinal tract; and I have had under my care a case of primary actinomycosis of the appendix. With invasion of the soft tissue the infection spreads to the neighbouring bones, and it is therefore often seen in the upper and lower jaws. The ribs, sternum, and spinal cord may be attacked, and according to Erving[1] the spine has been involved in about 2 per cent of the reported cases.

Symptoms.—A slow progressive thickening of the soft tissues and enlargement of the neighbouring bone takes place, with the ultimate formation of sinuses and a persistent purulent discharge. In it are found at times minute whitish masses, and the ray-fungus may be discovered in them, although repeated examinations are often required, sometimes as many as seven or eight, before the streptothrix can be detected.

In the jaw, the symptoms are usually mistaken for sarcomata or gummata. In the spine, the symptoms at first resemble Pott's disease, yet, when overlying tissues are involved, the area of redness and induration, and the number of sinuses are far more extensive than is ever met with in tuberculous caries.

[1] *Johns Hopkins Bull.*, November 1902.

The outlook is serious. However, if the nature of the disease is recognised comparatively early, and increasingly large doses of iodide of potassium are given, the disease is often checked, and may be cured.

Hydatid Disease of Bones

Hydatid cysts in bone are very rare. They affect the ends of the long bones, the bodies of the vertebræ and the pelvis, and are due to the development of the embryo of the taenia echinococcus. The cysts do not present the same appearances as hydatids elsewhere, for example, in the liver. Instead of one cyst there are frequently a large number of small ones, which are scattered throughout the medulla. According to Thomson and Miles the formation of brood capsules and hooklets rarely occurs. As the number of cysts increases, the normal structure of bone is gradually absorbed, so that fracture may result. When the cysts make their way into the surrounding soft tissues they no longer remain small, but attain a considerable size. As the cysts spread, they may give rise to necrosis and suppurative arthritis. Clinically, the symptoms are those of chronic bone-pain with egg-shell crackling and unequal enlargement of the bone. When the vertebral column is affected, angular deformity and paraplegia result. A radiogram of a case of hydatid disease of the bone shows that the osseous structure is absorbed by the progressive development of the cysts.

Treatment.—In early cases, the bone should be laid open and the cysts thoroughly scraped away; if suppuration with spontaneous fracture has occurred, then amputation must be performed.

Mycetoma

This affection is also known as Madura foot. At first it was thought to be due to an organism identical with that of actinomycosis, but it is now known that Madura foot arises from a fungus—distinct from the ray-fungus. It occurs chiefly in the feet of males who walk barefoot, and is especially prevalent in India and other tropical countries.

The first appearance of the disease is an indurated patch, which becomes discoloured, and shows black or yellow nodules containing the organism. The nodules increase in size and spread through the soft tissues. They suppurate and numerous abscesses are formed, the pus contains yellow or black granules which are likened to

Skiagram of a Pedunculated Exostosis, springing from the Adductor Tubercle of the Femur (Spencer and Gask, after Hugh Walsham).

To face page 573.

gunpowder; the foot then becomes riddled with sinuses, and at the bottom of the cavity carious or necrotic bone can be felt. The disease is a purely localised one, and runs an exceedingly chronic course. It does not yield in any way to iodides. The only treatment in advanced cases is to amputate the part.

Neoplasms of Bone

Tumours of bone are primary and secondary. The primary tumours are of the connective tissue type, the secondary tumours structurally resembling the primary growths which cause them.

Primary Tumours.—They originate either from the periosteum, the epiphysial cartilage, or from the medulla, the latter being called central. Some forms grow in the interior of the bone and expand the shell of compact tissue, in many cases breaking through it. The primary tumours are innocent and malignant. Of the innocent tumours, osteomata, chondromata, and fibromata require notice; whilst myxoma, lipoma, and angioma are so rare that special treatises on the subject must be consulted.

Innocent Growths

The *osteomata* or *exostoses* are of two kinds, the ivory or membranous exostosis and the cancellous exostosis, the latter arising from the ossification of a chondroma.[1] The ivory exostosis is developed from "membranous" bone, and is particularly prone to grow from the walls of the orbit and the skull, where it frequently causes serious inconvenience and troublesome symptoms. Its growth is gradual, and it forms a hard indolent tumour, fixed to the bone, and is generally sessile. The results of its growth depend naturally upon its pressure-effects. It may be known diagnostically by its situation, its slow growth, and its hardness. X-rays will be of assistance, not only in determining its nature, but also in considering the possibility of its removal.

The treatment of these growths is to remove them when necessary.

[1] On the subject of "Multiple Cartilaginous Exostoses," an excellent paper by my colleagues at the Westminster Hospital, Dr. A. M. Gossage and Mr. E. Rock Carling, should be read. It appeared in the *Proceedings of the Royal Society of Medicine*, Nov. 1910. The communication is too long and too full to make a short abstract profitable. Suffice it to say here that the pathogenesis is carefully dealt with, and the hereditary nature of the affection is discussed. Transmission to descendants is rather a striking illustration of Mendel's law. The paper concludes with a very full bibliography.

Many of them, however, can safely be left alone for years, or need not be touched at all. When important structures, such as the eye, are pressed upon and displaced, or the external auditory meatus is

FIG. 315.—Anterior view of the trunk and upper extremities of a lad affected by Multiple Exostoses, under the care of Mr. E. Rock Carling at Westminster Hospital.

blocked, the propriety and possibility of operation must be considered. They are so hard that many operative failures have been reported. It may be in some cases possible to remove the tumour and the bone from which it grows; but, in other cases long-continued attempts to plough a way through the base of the growth have not succeeded, owing to its extreme hardness. Ordinary saws and chisels are of little avail, so that patience and persistence with

FIG. 316.—Back view of the trunk and upper extremities. A bony growth has been removed by Mr. Rock Carling from the left scapula.

electrical drills, cutting instruments, and saws may save the patient and the operator much disappointment.

Cancellous exostoses, which should be distinguished from new formations in muscle and tendon, such as myositis ossificans, grow either from the neighbourhood of the epiphysial line or from the cartilage itself. To some extent their appearance seems to be determined by repeated irritation or by injury. The condition is

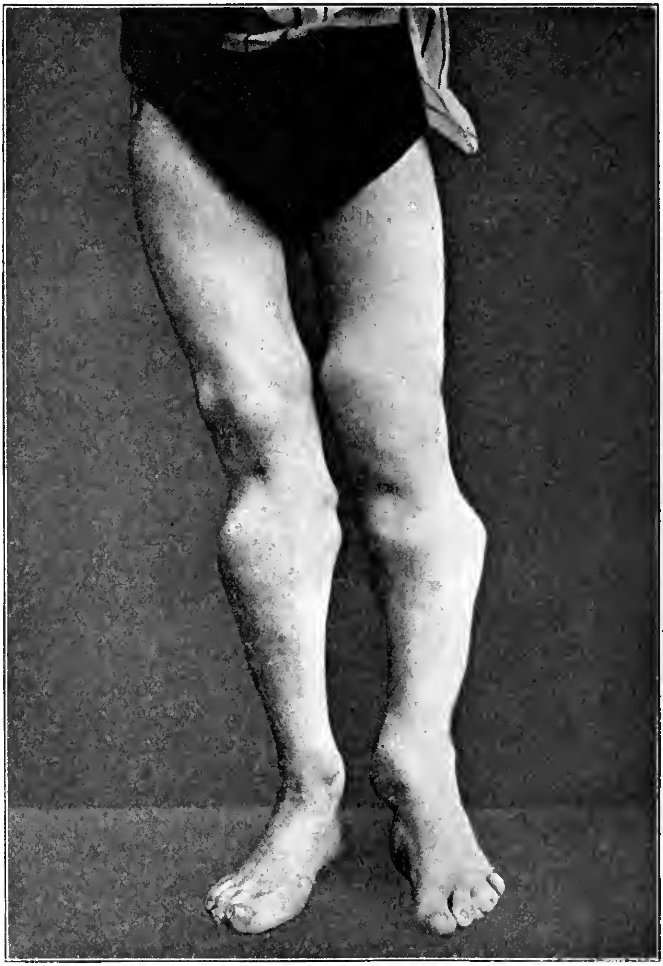


FIG. 317.—Anterior view of the lower extremities of the patient, seen in Fig. 315.

frequently hereditary, and is associated with curvature of the long bones. The favourite situations are the bones of the hands, phalanges of the feet, especially the terminal phalanx of the great toe (subungual exostosis), the inner side of the lower end of the femur, and about the shoulder and wrist; they are seen occasionally on the scapula and pelvis. They originate as enchondromata, which gradually undergo ossification, and the growth of the tumour does not cease until the whole of the cartilage is converted into bone, so that they may vary very much in size from a pea to a fœtal head.

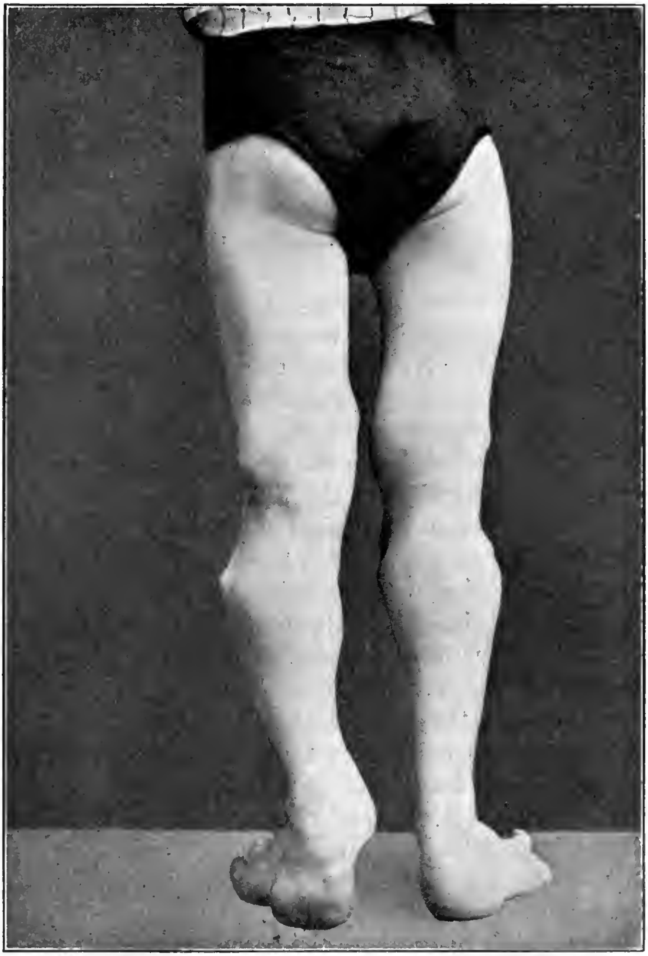


FIG. 318.—Back view of the lower extremities of the patient, seen in Fig. 315, showing Multiple Exostoses.

Clinically, they are indolent growths, which cause inconvenience only from the pressure-symptoms to which they give rise, and their treatment consists of free exposure and cutting through the base with a chisel. Developmentally, they originate from the remnant of the cartilage at the epiphysial line. If the remnant is within the compact tissue of the bone, as occurs sometimes in the case of the fingers, these growths appear to arise, not from the periosteum, but from within the cancellous tissue. In most cases, however, their origin is clearly superficial. The diffuse form of exostosis is seen in leontiasis ossia (Vol. II. p. 570). A rare form of exostosis is unilateral hypertrophy and osteoma of the skull (Jonathan Hutchinson and Alexis Thomson). Its distribution is unilateral, and follows very closely that of the fifth nerve.

Chondromata.—The majority undergo ossification, and have been referred to in the description of osteoma. Another type, seen occasionally, undergoes degeneration of a myxomatous or sarcomatous type, so that we meet with myxo-chondroma and chondro-sarcoma, these being malignant in character, and particularly so when growing from the scapula.

FIG. 319.—Multiple Enchondromata of the hand (Spencer and Gask, after Druitt).

An innocent cartilaginous growth is a slowly developing smooth or lobulated tumour, often multiple and elastic in feel. It originates, as a rule, from the surface of the bone, but when forming in the interior of a bone it is called enchondroma. On the bones of the hands they may cause such pressure on the skin as to give rise to ulceration. Any change in the consistence of the tumour, particularly from firmness to softness, should give rise to a suspicion of myxomatous or sarcomatous change, and this is confirmed if the rate of growth of the tumour is suddenly accelerated.

The treatment of cartilaginous tumours consists of their removal, so soon as they cause inconvenience; and in most cases it is comparatively easy, unless the growths are multiple in character, or are in awkward proximity to important vessels and nerves. Occasionally it may be advisable to remove the bone from which they arise; as, for instance, a phalanx.

Chondromata of the scapula present difficulties in dealing with them. It is better to remove the primary growth and have it examined, and then to determine upon the necessity of removal or not of the scapula, at a later operation.

Fibromata.—One type of this form of bony new growth is the simple epulis of the jaw. They vary from firm fibrous masses to soft and very vascular structures.

PLATE XXVII.

From a skiagram by Mr. C. Thurstan Holland. Chondro-Sarcoma of the Right Femur of a female adult. The swelling had been noticed for five months.

To face page 579.

Other new growths in bone, such as myxomata, lipomata, angiomata, and cystic growths, excite interest by their rarity.

Malignant Neoplasms

Malignant new growths are primary and secondary. Primary growths comprise sarcoma and endothelioma. Secondary growths arise either from direct extension from the adjacent soft parts, or are due to metastatic deposits; and therefore they partake of the nature of the original growth.

Sarcomata of *one type* are composed of soft, rapidly-growing cellular material with little or no fibrous stroma. The cells are spindle-shaped, round, or oval. The growths originate in bone from the medulla, from the epiphysis, from the periosteum, or from the cancellous tissue of the skull, the pelvis, the vertebræ, and jaws. We do not describe here the giant-celled growth, as we shall allude to it presently under the name of "myeloma"; since, though formerly it was included in malignant new growths, experience shows that it is not necessarily so. Certainly it is not, so long as it remains encapsuled. In contrast to this form is the round-celled sarcoma, which is intensely malignant. It grows with great rapidity, and secondary deposits are early and characteristic features. As a rule a sarcoma which is purely cellular does not cause much enlargement of the bone; it eats away its structure, so that sometimes the first sign to draw attention to the condition is a spontaneous fracture.

Sarcomata of *the second type* are those in which connective tissues, such as fibrous tissue, cartilage, and the bone are combined with the cellular elements. They originate usually from the deeper layers of the periosteum, and are called "periosteal"; rarely, they spring from the superficial layers and the structures running into them, and are then known as "parosteal." Many of them undergo ossification, giving rise to a peculiar coral-like formation of bone. So soon as the periosteal sarcomata break through the fibrous layer of the periosteum, they invade the neighbouring tissues, and may appear on the surface of the part as fungating masses. In many cases there is a distinct history of injury preceding their appearance. The periosteal sarcomata usually contain spindle cells, but they may be round, oval, or mixed. In addition to bone, well-developed fibrous tissue and cartilage are found in the growth, so that we meet with fibro-, osteo-, and chondro-sarcomata.

Starting from the exterior of the bone, they grow towards the surface of the limb and cause a projection or swelling of the part; and, at the same time, they invade the medullary canal, so that the marrow is replaced with a white new growth. The tissues on the outer side of the bone become ossified into the coral-like formation we have mentioned, whilst the most external portion of the sarcoma consists chiefly of spindle or round cells.

Clinically, they appear most often in children and in adults before the age of thirty; and the younger the patient, the greater the malignancy. In fact there is no more malignant tumour than a parosteal sarcomatous tumour of the femur appearing in a child. Metastatic growths rapidly form, chiefly in the loins. Secondary infection is usually conveyed through the veins, and not through the lymphatics. It is rare to find lymph glands infected, yet occasionally they become enlarged from secondary growths. The usual sites of sarcoma of bone are the neighbourhood of the knee-joint, the upper end of the humerus, and the fibula. Periosteal and parosteal sarcoma usually begin on one side of the bone, and later involve it more or less. By their rapid growth, especially at the lower end of the femur, they give rise to the so-called "leg of mutton" appearance. The uneven consistence of the swelling should excite suspicion, which an X-ray examination or an exploratory incision will confirm. As the swelling increases, a fine egg-shell crackling may be felt on firm pressure, due to the crushing of the coral-like new bone. The swelling gradually tapers away at its periphery into the substance of the limb, thus differing from inflammatory periostitis, which often terminates in a definite line of demarcation.

For a time the soft tissues over the growth are unaffected; later, they become œdematous, and are traversed by a venous network. It is striking to note that some rapidly-growing periosteal and parosteal sarcomata are accompanied by inflammatory signs in the tissues over the growth, and by a rise of local and general temperature. We have met with at least two examples of the latter: in one the temperature in the axilla rose to 102·8, and in another to 101·4.

Diagnosis.—An early diagnosis is all-important. The most valuable means is a radiogram. In periosteal sarcoma the diffuse outline of the tumour can be identified in the radiogram, and the coral-like formation of new bone seen; moreover, the periosteum at the periphery of the tumour is lifted away from the bone and gradually lost in the substance of the growth.

PLATE XXVIII.

From a skiagram by Mr. C. Thurstan Holland. Parosteal Sarcoma of the Right Femur, occurring in a woman aged 22 years, under the care of Mr. Robert Jones. The limb was amputated. Note the coral-like formation of bone in the growth.

To face page 580.

If the appearances in the radiogram still leave us in doubt, it is advisable to make an exploratory incision, remove a small portion, and examine it immediately under a microscope, the surgeon being prepared to continue the major operation, if the growth is found to be sarcomatous. Much valuable time may be lost unless we take these decisive measures, for it is not always easy to differentiate chronic periostitis, osteitis, myelitis, tuberculous or syphilitic inflammation of bone from new growth; and we have known surgeons to be in error, who have relied upon the clinical signs alone.

The occurrence of a spontaneous fracture in a young adult should always give rise to suspicion of central sarcoma, and call for an X-ray examination.

Prognosis.—The outlook varies (1) with the nature of the growth, the periosteal being more malignant than the central ones. (2) With the situation of the growth, or to put it in other words, with its accessibility. Tumours of the bones of the head or pelvis are frequently beyond the possibility of operation. (3) Age: the younger the patient, the more malignant is the growth, generally speaking; and in a limb, the nearer it is to the body, the more uncertain is the outlook. A periosteal sarcoma of the hip or of the femur in a child usually causes death within nine months.

Treatment.—In dealing with periosteal and central sarcomata, amputation may be the only safe course; and the question arises as to whether it is sufficient to saw through the bone at a considerable distance above the growth, or to amputate through the joint above.

As Thomson and Miles point out,[1] there are reasons, however, which may be urged against amputation as an ordinary procedure. High amputation is unnecessary in the more benign sarcomata, and in the more malign forms it fails to prevent a fatal issue, either from local recurrence or from metastases in the lung or elsewhere.

Following the lead of Mikulicz a considerable number of permanent cures have been obtained by resecting the portion of bone which is the seat of the tumour, and substituting for it a corresponding portion of the tibia or fibula. When resection is impracticable, a sub-capsular enucleation is performed. The part is then exposed daily to the X-rays for at least three months. In inoperable cases recourse may be had to the injection of Coley's fluid.

[1] *Manual of Surgery*, 3rd ed. vol. i. p. 685.

Sub-capsular Enucleation.—Thomson and Miles thus describe it: "The capsule of the tumour is incised, and the tumour tissue is rapidly scooped out with the fingers. The capsule, after being wiped out with dry gauze, is painted with the following solution: Pyoktanin 5 parts; phenol 1 part; alcohol 20 parts; water to 100 parts. The cavity is usually packed with sterile gauze to arrest hæmorrhage. The X-rays are then applied daily for months, and after apparent cure, exposure should be made once every two to eight weeks for several years. As a general rule, the anode should be placed about 30 cms. from the skin, and the time of exposure should average from twenty to fifty minutes. The application is divided between different areas, so that the rays may penetrate the diseased part in every possible direction."

Endothelioma may arise from synovial membranes, from blood-vessels, sinuses, and lymphatics. If of vascular origin, they may give rise to pulsating aneurisms.

Myeloma[1]—formerly called *myeloid sarcoma*, and almost invariably classified with the malignant growths, is now generally placed amongst the innocent tumours of bone; although it sometimes gives rise to metastases, containing giant cells. It is as a rule innocent, and does not cause the constitutional cachexia inseparable from a secondary sarcomatous growth.

The tumour usually arises in early middle life, and most frequently in the lower end of the femur, the upper end of the tibia, the lower end of the fibula, and the distal extremity of the radius. The characteristic histological feature of these growths is the large multi-nucleated giant cells similar in appearance to the hæmatoblasts of the marrow. In addition to these characteristic cells, small ones, often round and oval in shape, are found, and occasionally fusiform cells are seen. The growth is maroon in colour, soft, and often presents cysts which are filled with serum or blood. If, as is frequently the case, the arterial vessels are large and numerous, pulsation and a bruit can be detected. The tumour grows rapidly, and expands the shell of bone, so that it becomes much thinned,

[1] Cf. "Myeloma of the Long Bones," by Frank S. Matthews, *Ann. Surg.* vol. lii. No. 3, Sept. 1910, pp. 388-396. He gives the following recent references: Adami and Nichol's *Principles of Pathology*, 1909; Ribbert, *Geschwultzlehre*, 1904; Bland-Sutton, *Tumours, Innocent and Malignant*, 1906; Coley, "Conservative Treatment of Sarcoma of Long Bones," *Jour. Amer. Med. Ass.*, Jan. 29, 1910; Bloodgood, *Progressive Med.*, Dec. 1907 and Dec. 1909; Rotch, *Röntgen Rays in Pediatrics*, 1910; De Nancrede, "End Results," etc., *Ann. Surg.*, July 1909; Trotter, Diagnosis of Common Swellings of the Long Bones, *Clinical Jour.*, 1907.

PLATE XXIX.

Skiagram by Mr. C. Thurstan Holland of Periosteal Sarcoma of the Right Knee of an adult male. After amputation, the specimen was split antero-posteriorly and opened out. Note the fracture of the femur.

To face page 582.

Inner half of the specimen seen in Plate XXIX. From a skiagram by Mr. C. Thurstan Holland.

To face page 582.

PLATE XXXI.

From a skiagram by Mr. C. Thurstan Holland. Carcinomata of the Radius, secondary to scirrhus of the breast, in a woman, aged 55 years.

To face page 583.

PLATE XXXII.

From a skiagram by C. Thurstan Holland. Secondary Carcinoma of the Humerus ; a lump had been noticed for three months.

To face page 583.

and may cause the characteristic egg-shell crackling. Clinically, the growth is slow, and for a long time painless. On account of its size it may cause mechanical interference with the movements of the joint. The appearances in a radiogram are not very characteristic, and may easily be mistaken for a cyst. If the growth perforates the shell of compact bone, invasion of the neighbouring tissues, and ultimately of the skin, takes place, and a fungating bleeding surface is formed.

Treatment.—In early cases the growth may be enucleated from the bone; and in later cases the affected segments of the bone should be resected and a bone-graft inserted to fill the gap.

Myeloma is usually single, a rare form is the multiple, which affects the ribs, sternum, and bodies of the vertebræ. The cancellous tissue is replaced by a reddish gelatinous substance; sarcomatous in appearance. The compact shell of bone is expanded and partially absorbed, so that fracture readily takes place. A striking point is that the urine contains albuminoids.

Secondary Malignant Growths.—Any form of neoplasm of this description may be found in the skeleton, and the nature of the secondary growth is always determined by that of the primary.

Pulsating Sarcoma and Aneurism of Bone.—Some of them owe their origin to the growth of congenital naevi or angioma. Others are due to the formation of vascular cysts in a myeloma, endothelioma, or sarcoma. Large sinuses or spaces gradually develop at the expense of the tumour substance, which is pushed to one side by the expansion of the cavity. These pulsating tumours are generally found in the epiphysis of the long bones. Clinically, they present the pulsation and bruit, characteristic of true aneurism; in addition, egg-shell crackling may be present. X-rays reveal the presence of a cystic cavity or cavities in the bone.

Treatment.—It is often difficult to decide whether they are innocent or malignant. If the former is believed to be the case, the main artery of the limb should be ligatured; if the latter, the ligature of the main vessels and enucleation may be tried first; it should be clearly understood, however, that the conditions found on exploration may be such that amputation may be required.

A rare form of secondary tumour is a *thyroidoma,* in which deposits of thyroid-like structure are found in the bone, secondary to a small primary growth in the gland. Formerly it was believed that they were invariably malignant, later experience has shown that they are not necessarily so.

Cancer of the bone may also originate from direct extension of disease from the soft parts.

Malignant Disease of the Spine

Malignant disease of the spine is rare in any case, and primary malignant disease is especially so. The new growth may be:—

I. Sarcomatous, primary or secondary.
II. Carcinomatous, secondary to a carcinoma elsewhere, *e.g.* breast.
III. Epitheliomatous, secondary to growth in the rectum.

Fig. 320.—Sarcoma of the Spine, showing the deformity (J. K. Young).

Clinically the neoplasm may appear as a tumour, palpable through the abdominal wall, or by the vagina or rectum; there may be pressure-signs and venous obstruction in the thorax; or, as is often the case, the invasion of the vertebral body by soft growth, which replaces the rigid osseous tissue, leads to collapse and angular deformity, impossible to be distinguished from that of Pott's disease.

As a matter of fact, most of the recorded cases were diagnosed and treated as caries, and that by quite competent observers, the true state of affairs being ascertained *post mortem*.

FIG. 321.—The same patient as in Fig. 320, showing dilated veins on the chest and abdomen, and evidences of growths in the orbits (J. K. Young).

The patients affected are usually in middle life or older.

Sarcoma is, however, met with earlier, thus J. K. Young[1] records primary sarcoma in a child of five (Figs. 320, 321), and Reiss[2] one in a girl of twelve, and a case in an infant is figured by Bradford and Lovett.[3]

Females are stated to be more frequently affected than males, which may perhaps be accounted for by the great frequency of carcinoma of the breast in women.

Any region, from the cervical to the sacral, may be attacked. Bland-Sutton[4] has noted its occurrence in the cervical region. The area affected is generally either the dorsal or the lumbar, but, as to the relative frequency observers do not agree.

As a rule the deposit is single, or practically so; nevertheless widely disseminated foci may exist, especially in secondary cases. In a case recorded and figured by Wullstein,[5] countless (unzählige) small sarcomatous foci were present. The ninth and tenth dorsal vertebræ were practically destroyed, angular deformity was present, the diagnosis being Pott's disease; and, it was only at the *post mortem* examination that the real nature of the disease was ascertained. In this case, then, although multiple, unless a primary sarcoma elsewhere was overlooked, which is unlikely, the spine was primarily affected.

In general, the spinal disease is secondary to carcinoma or sarcoma elsewhere, yet the reverse process may take place. In J. K. Young's patient, the diagnosis was at first Pott's disease, until a metastatic sarcoma of the orbit formed.

Symptoms and Diagnosis.—The earliest symptoms are local pain, rigidity, and tenderness. As the case progresses, the leading features are the distal pains, sometimes root symptoms, at other times deformity, and the futility of treatment to afford relief.

Pain.—From the onset, pain is a very characteristic feature.[6] Charcot named this characteristic symptom—that is, the pain due to infiltration of the vertebræ, complicating, *e.g.* cancer of the breast —"paraplegia dolorosa";[7] this is misleading, however, as actual paraplegia may be absent.

[1] *Trans. Amer. Orth. Assoc.* vol. xiv.

[2] *Zeitschr. f. orth. Chir.* Bd. xv. p. 162.

[3] *Op. cit.* p. 154.

[4] *Tumours, Innocent and Malignant,* p. 116.

[5] Joachimsthal's *Handbuch orth. Chir.* part ii. pp. 1327, 1328, 1329.

[6] "Carcinoma of the Spine and Meninges, secondary to Cancer of the Breast," Pearce and Buckley, *Jour. Am. Med. Assoc.*, Feb. 20, 1904.

[7] Bradford and Lovett, *Orth. Surg.* 3rd ed. p. 155.

Besides the local pain, at first aching in character, and much increased by movement, and the agonising pain due to the settling down of the column, pains radiating to the lumbar and abdominal regions and lower limbs, nerve-root pains, occur. To them must be added, in cases where the cord is pressed upon, the special pains associated with commencing paraplegia.

Tropho-neurotic symptoms from vaso-motor disturbance, as evidenced by the liability to the formation of bed sores, are common. Herpes has been seen.

Cord Symptoms.—If the spinal canal is encroached upon, paraplegia may arise. Sir William Bennett[1] states that the cord is compressed but never infiltrated.

Swelling or thickening posteriorly may be seen, or felt *per orem, vaginam* or *rectum*; or, pressure symptoms may indicate a growth pressing on the thoracic contents.

FIG. 322.—Sarcoma of the spine (Bradford and Lovett).

Deformity.[2] — Replacement of the bony structure of the bodies by soft sarcomatous tissue is followed by settling down, and the appearance of an angular projection, just as in tuberculous spondylitis. There is a further similarity in the two diseases; in both of them the discs are more resistant to destruction by the pathological process than are the bones. The remarks made elsewhere on the mechanism of deformity (Vol. II. pp. 80-87) hold good in malignant disease.

In carcinomatous infiltration, deformity is less frequent and pronounced.

[1] Holmes, *System of Surg.* 3rd ed. vol. ii. p. 271.

[2] Cf. figures—Holmes, *System of Surg.* 3rd ed. vol. ii. p. 272; Joachimsthal, *Orth. Chir.* part ii. p. 1329; *Trans. Amer. Orth. Assoc.* vol. xiv. p. 279; Bland-Sutton, *Tumours*, p. 115; Bradford and Lovett, *Orth. Surg.* 3rd ed. p. 155.

Resistance to Treatment.—In other words, the affection is malignant; still, the course is not necessarily constantly and without cessation downhill.

Course and Duration.—As we have stated, save in the plainly secondary cases, the diagnosis of Pott's disease is usually made, and this may appear to be confirmed by a temporary amelioration, when the treatment suitable for caries is adopted. The partial relief of pain by fixation, and the effect of general measures sufficiently explain this. It is, however, but a temporary phase.

Sampson Handley,[1] in dealing with repair in carcinoma, points out that spinal metastases may shrink and lead to spontaneous improvement in pressure-symptoms. Osler records a case in which paraplegia was thus relieved. "The primary operation was in February 1898. In August 1899, the patient began to have the usual nerve-root pains; and in November she had a severe attack of herpes on the left side. After a winter of great suffering, she became completely paraplegic, and for weeks was desperately ill." The paraplegia, however, gradually disappeared and did not recur, the patient living three or four years.

As to duration—Young's case of sarcoma lived fourteen months from the first observation. The carcinomatous case, just quoted, lived some years; as a rule, the duration of life does not exceed six months, from the first onset of spinal symptoms.

Differential Diagnosis. — It should be made from innocent growths of the spine, neuralgia, cervical pachymeningitis, syphilis, aneurismal erosion of the vertebræ, and tuberculous spondylitis. We shall only deal with the last. The tenderness is less than in Pott's disease, although the pain on movement is greater. The pain, often agonising, is a more prominent feature of the case throughout in malignant disease, and the inflammatory signs, pyrexia, and abscess formation are absent; whilst the cachexia is marked, and is not, as in Pott's disease, due to hectic fever and prolonged suppuration.

Treatment.—At present, reliance must be placed on general measures, rest, support, and morphine. It is interesting to note that the late Mr. Davies-Colley [2] removed a sarcoma compressing the cord, and the patient recovered motion and sensation.

[1] *Cancer of the Breast*, p. 160.

[2] *Trans. Roy. Med. Chir. Soc.* vol. xxv. p. 163. Quoted by Bland-Sutton.

Additional References to Malignant Disease of the Spine

Michel. Nouv. dict. de méd. et chir. xxxix. 222.
Edes. Boston Med. and Surg. Jour., June 17, 1886, 559.
Charcot. Comptes rendus de la Soc. de Biol., 1865, 28.
Bechterew. Neurol. Centralbl., 1893, 313.
Födert u. Peham. Deutsch. Zeitschr. f. Chir. xlv.
Amidon. New York Med. Jour., 1887, pp. 225-231.
Judson. Trans. Amer. Orth. Ass. vol. ix.
Howard Marsh. Lancet, 1893, vol. ii. p. 792.

Malignant Disease of the Hip

Happily this affection is a rare occurrence. Of 70 cases of sarcoma of the femur, analysed by Gross, in two only was the upper end affected.

Pathology.—Sarcoma is the usual form, carcinoma being the rare form. The former grows from the periosteum, and is of the round-celled variety. It is of rapid growth and intensely malignant. These growths are very vascular, often alveolar in structure, and frequently pulsating. The soft parts are infiltrated early, and sometimes the first sign of the occurrence of the disease is a spontaneous fracture.

Symptoms.—The disease frequently occurs in young adults and is often preceded by a definite injury. The symptoms are early and rapidly increasing swelling of the part, and, as the growth enlarges, there is limitation of movement of the joint. The tumour often assumes large proportions, and the skin is much distended over it. When the nerves are pressed upon or stretched, there is severe pain; if they are not irritated, the pain is so slight as to give rise to little distress. In some cases, distinct elasticity is felt over the tumour; true fluctuation, however, is absent, unless breaking down has occurred in its interior, and the spaces so formed are filled with blood. In this event pulsation also becomes marked.

In rapidly growing sarcomata, it sometimes happens that the temperature of the body is raised. Although we have not met with this symptom when the growth was at the hip, yet we have twice seen it in sarcoma of the lower end of the femur, where the evening temperature has risen to 102·4° and 101·8.°

The **diagnosis** is established by a careful consideration of the history of the swelling, its outline and feel. Early cases are often mistaken for tuberculous disease of the hip, nevertheless, the employment of X-rays readily establishes the nature of the disease; or failing this, exploratory operation, with examination of a portion of the tissue, is advisable. Pulsation may lead to error in the belief that an aneurism is present, but the classical signs of this latter affection, with which we are all acquainted, are wanting.

Treatment.—The results are very unsatisfactory. The only hope lies in very early diagnosis, before infiltration of the soft tissues has occurred. Wyeth [1] collected 22 cases of malignant growth of the hip, in which amputation had been performed, and the patients lived from three to sixteen years afterwards. In the majority of these cases, however, the growth affected the upper end of the shaft, and not the epiphysis. When the disease began in the epiphysis only, very few cases have been reported as cured.

Resection of the Joint.—When the soft tissues do not appear to be involved, this operation has been advocated by Mikulicz and Weissinger. It is highly unsatisfactory, as metastatic growths appear very soon after the operation. In many cases it is difficult to carry out an amputation at the hip joint, as, when the patient comes under observation, the soft tissues are extensively involved; and, even if disarticulation of the limb can be performed in an early case, the outlook in the majority of instances is hopeless. It does not appear that, when amputation is supplemented by local injections of Coley's fluid, the prognosis is in any way improved.

[1] Wyeth, *Ann. of Surg.*, 1901, vol. xxxiv. p. 375; and Jenckel, *Deutsch. Zeitschr. f. Chir.*, 1902, Bd. liv. p. 66.

SECTION X

PARALYTIC DEFORMITIES

CHAPTER I

DEFORMITIES ARISING FROM INFANTILE PARALYSIS (ACUTE ANTERIOR POLIOMYELITIS)

Infantile Paralysis—Ætiology—Epidemiology—Pathogenesis—Pathology—Bacteriology—Symptoms—Prognosis—Diagnosis—Treatment.

In this section [1] we shall limit ourselves to the consideration of acute anterior poliomyelitis and its effects, infantile spastic paralysis, tabes dorsalis, hereditary ataxia, syringomyelia, some forms of multiple neuritis, certain dystrophies, and the results of injuries to nerves. We do not propose to discuss injuries of the spinal cord and their effects; and we have already described compression paraplegia in writing of caries of the spine.

Infantile Paralysis

Synonyms—English, *Acute Anterior Poliomyelitis, Essential Paralysis of Children, Acute Atrophic Spinal Paralysis*; German, *Kinderlähmung, Spinale Kinderlähmung*; French, *Paralysie spinale, Paralysie infantile, Paralysie essentielle de l'enfance, Téphromyélite antérieure aiguë* (*Charcot*).

Anterior poliomyelitis is an infective epidemic [2] disease which chiefly affects children. Of 268 cases we have noted, 57 occurred in the first year, 95 in the second, 53 in the third, 29 in the fourth, 22 in the fifth, 5 in the sixth, 2 in the ninth, 1 in the eleventh, 3 in the fifteenth, and 1 in the eighteenth year. When it appears later in life, the cases are sufficiently rare to excite comment. In fact the affection is ten times as frequent in the first decade as in the remainder of life.

Ætiology.—The disease has a most striking relationship to

[1] I desire to express my thanks to my friend and colleague, Dr. Purves Stewart, for his kindness in reading the proof sheets of this section, and for some valuable suggestions, of which I have gladly availed myself.

[2] F. E. Batten, "Epidemiology of Poliomyelitis," *Brit. Med. Jour.*, Sept. 2, 1911.

climate. A number of children coming under my personal observation were born of Anglo-Indian parents, and were living in the tropics at the time of the onset of paralysis. Also it has a remarkable relation to the season of the year. In this country three-quarters of the cases begin during the months from June to September, and I have frequently noticed the connection between the custom of

FIG. 323.—Anterior Poliomyelitis of the right lower extremity, with weakness of the back, from a case under the author's care.

allowing children to "paddle" and the onset of infantile paralysis. In America, Sinkler[1] found that in Philadelphia four-fifths of the cases occurred during the five hot months.

Exposure to cold, particularly if the patient has been overheated previously, is sometimes noted as an antecedent. Overexertion in walking seems to aid in exciting the disease; thus in a case, which came under my notice, a child of six was taken for

[1] Keating's *Encyclopædia*, p. 683.

a long walk on a very hot day, and in the afternoon complained of feeling tired, and then sank to the ground, saying she could go no farther. After resting for an hour, she was induced to get up and walk the short remaining distance home. Next morning she felt tired, but there were no symptoms of paralysis. She was, however, taken out again for a walk, and in about an hour's time fell and was carried home. Some feverishness with vomiting and pain in the back followed; and on the third day both legs and the left arm were found to be paralysed. Sometimes a shock or a fall precedes the onset, and very frequently it appears during the first dentition; this may, however, be a mere coincidence, as there is no increase in frequency at the period of the second dentition, There seems, nevertheless, to be a connection between a recent attack of scarlet fever or measles and the onset of infantile paralysis.

FIG. 324.—Infantile Paralysis of the lower extremities, with talipes equino-varus (Rédard).

The previous health of many of the children who have suffered has been exceptionally sound. A few have been very much out of health and suffered from diarrhœa. Generally, the paralysed child is described by the parents as having been of a very lively and energetic disposition, often very sensitive and excitable. The disease occurs in epidemics; several of these have been recorded by Medin,[1] Leegard,[2] Cordier (quoted by Marie),[3] Pasteur,[4] Brackett,[5]

[1] *Verhandlung. des X. Internat. med. Kong.*, Berlin, 1890, vol. ii. p. 37.
[2] *Münchener med. Wochenschr.* No. 38, 1898.
[3] *Lyon médicale*, 1888.
[4] *Clin. Soc. Trans.* vol. xxx. p. 143.
[5] *Trans. Am. Orth. Ass.* vol. xi. p. 133.

Caverley,[1] Taylor,[2] Altman,[3] and by Lovett and Emerson.[4] The only point in common of these epidemics is that they occur during the hot season and generally in the neighbourhood of rivers and swamps. The author has recently heard of three other epidemics, one in the year 1905 in the eastern part of Cape Colony which affected 40 children, another in Natal when 27 children suffered, and a third in Stamford in Lincolnshire where 15 children were affected. And the number of epidemics reported is rapidly increasing.[5]

[1] *Journ. Am. Med. Ass.*, Jan. 4, 1898. (During an epidemic of 140 cases in Vermont a large number of domestic animals also died paralysed.)

[2] Taylor, *Boston Med. and Surg. Journ.* vol. cxxix. p. 504.

[3] *Aust. Med. Gaz.*, April 24, p. 173.

[4] R. W. Lovett and Herbert C. Emerson have compiled a most interesting report on infantile paralysis, with particular reference to the epidemic in Franklin County, Massachusetts. The full reference is "The Occurrence of Infantile Paralysis in Massachusetts in 1908. Reported for the Massachusetts State Board of Health," *Monthly Bulletin of the Mass. State Board of Health*, July 1909. Cf. also an earlier paper, *Boston Medical and Surgical Journal*, July 30, 1908, and another in the same journal on July 22, 1909. Want of space prevents us giving a full analysis of these valuable papers. The epidemic nature of the disease is dwelt upon, together with the simultaneous affections of domestic animals. The conclusions arrived at are that: 1. Infantile paralysis is a disease produced by some external agent—that is, it is an infectious disease. 2. It is mildly contagious, at most. 3. The harmful agent appears to enter the digestive tract in many instances. 4. Until the organism causing the disease is known, it is impossible to say whether the infection is carried directly to the patient or by means of food.

[5] A weekly report of the United States Public Health and Marine Hospital Service, published on March 3rd and summarised in the *Boston Medical and Surgical Journal*, contains a tabulated statement of the cases of poliomyelitis and the deaths caused by the disease, recorded in the United States during the year 1910. Pennsylvania heads the list both in prevalence and in mortality; there were 1097 cases and 172 deaths in that State. In Iowa there were 638 cases and 161 deaths. In Massachusetts there were 588 cases; the number of deaths is not given. Apparently, the epidemic was most continuous in Iowa, for that is the only State from which cases and deaths were reported for every month of the year. The maximum number of cases in any month was 378, in September, in Pennsylvania; the maximum number of deaths —64—in the same month and the same State. The maximum number of cases in any month in the entire Union was 1146, in September; the maximum number of deaths, 182, in August. The total number of cases and deaths from poliomyelitis in the United States during the calendar year was 5093 and 825 respectively, a mortality of about 13·75 per cent (Epitome, *B.M.J.*, April 1, 1911). Holt (*Arch. of Ped.*, September 1910) writes that, as a consequence of the greater interest taken in this subject, cases of poliomyelitis are now recognised, which formerly might have been overlooked. It is evident that a wave of infection, starting apparently from Scandinavia, is gradually spreading over other countries. Already 31 outbreaks, with 4940 cases, have been recorded in the past five years, which is an enormous increase upon past records. There is no essential difference between the sporadic and epidemic forms of the disease, except possibly in communicability and severity. It is probable that there is a difference in the virulence of the infection in the two forms. It would appear from published statistics that the virulence of the infective agent of

Whilst the sporadic cases are nearly always spinal, the epidemic cases take the cerebro-spinal form, being ushered in by convulsions and often followed by paralysis of the cranial as well as of the spinal nerves. In this form, too, delirium, stupor, and hyperæsthesia are marked.

Pathogenesis.—Evidence has gradually accumulated that the origin of the disease is to be found in vascular disturbance due to some toxic agent. The prevalence of infantile paralysis, especially in the summer months, when diarrhœa of the type which is known to be caused by micro-organisms, is suggestive, as indicating that there may be a poison absorbed from the alimentary canal [1] or from the naso-pharynx [2]; and that this poison is concerned in the production of the morbid condition of the vessels of the cord, which always accompanies the disease.

Recent investigations favour the infective theory of the causation of poliomyelitis. We have noted its occurrence in epidemics, and cases have occurred in the same house within three days of each other.[3]

The two theories advanced as to the exciting cause are the toxæmic theory and the bacterial theory.

P. Schultze performed a lumbar puncture in a case thought by him to be anterior poliomyelitis, and isolated an organism which had the characteristic growth of the Weichselbaum-Jäger diplococcus. But, as a

poliomyelitis is greater when the disease is epidemic; therefore the mortality is higher and the communicability greater. The disease varies much in severity in different epidemics. A similar variation has been noted in the virulence of cerebro-spinal meningitis. The death-rate ranges from 6 to 29 per cent, and is much lower in sporadic cases. The existence of cases, in which complete recovery takes place, even after paralysis develops, has been well recognised during recent years; abortive cases are also recognised, although the symptoms are not sufficiently characteristic to enable these cases to be diagnosed when seen by themselves. Occurring sporadically, such cases would not be diagnosed; they would be hardly suspected. In epidemics they would be recognised only by their association with paralytic cases. The disease is, under certain conditions, highly contagious and demands the strictest quarantine. The writer considers that the disease might be better named "epidemic myelitis" or "epidemic myeloencephalitis," instead of "acute anterior poliomyelitis" or "acute poliomyelitis," as at present. G. Parker, *B.M.J.*, March 18, 1911, p. 609, describes an epidemic occurring in Bristol in 1910.

[1] Warrington of Liverpool (Tubby and Jones, *Surgery of Paralyses*, p. 10) had under observation a pig suffering from a form of subacute paralysis. The intestines were found loaded with nematodes.

[2] Osgood and Lucas (*Jour. Amer. Med. Ass.*, Feb. 18, 1911, vol. lvi. pp. 495-497) have shown by experiments that it is possible to transmit from monkey to monkey a typical poliomyelitis by using the filtrate of the naso-pharyngeal mucosa of two monkeys, dying without other discoverable infections, respectively six weeks and five and a half months after the acute stage of the disease. Flexner and Lewis (*Journ. Amer. Med. Ass.*, Feb. 12, 1910, p. 535) were the first to point out that the naso-pharyngeal mucous membrane may be a possible route of direct infection in man. Cf. also Macleod Yearsley, *Brit. Med. Journ.*, March 18, 1911.

[3] *Surgery of Paralyses*, p. 6.

somewhat similar form of paralysis follows certain cases of cerebro-spinal meningitis, this observation is not conclusive. F. Engel has found staphylococcus albus in the cerebro-spinal fluid in an undoubted case of poliomyelitis (cf. Bacteriology).

Pathology.—It is chiefly the cells of the anterior cornua which are attacked. Batten, quoted by Gossage,[1] ascribed the changes in the cord to thrombosis occurring in the area supplied by the anterior spinal artery, and Goldscheider[2] argued that the lesion was closely connected with the distribution of the central branches of the anterior spinal artery. He found that the lesion was not confined to the ventral horns, but invaded the white matter and the dorsal horns, *i.e.* the area, supplied by the central branches of the spinal arteries which course mainly in the long axis of the cord, was affected. If we examine the cord at any level, we find it supplied by branches from several central arteries. Goldscheider made the important discovery that, where one such artery escaped the attack, the cells in the area it supplied, remained healthy. In this way various groups of cells were affected at different levels. He considered that, owing to the entrance of some irritant into the vessel walls, they became much dilated and their endothelial elements proliferated. From this as a centre the neuroglia became affected, and the changes in the ganglion-cells and nerve-fibres he looked upon as secondary—a kind of necrosis, taking place in consequence of impaired nutrition. That is, the change is primarily interstitial. Other observations seem to prove that a primary parenchymatous change occurs in the nerve-cells as well. The balance of opinion, however, is in favour of a primary interstitial change.

The morbid process may involve a few segments of the cord or a considerable part of it, and even extend to the medulla and pons. As to the microscopical changes; the case, recorded by Dr. D. Drummond,[3] shows the changes in the fourth and fifth cervical segments of the cord, a few hours after the onset of the illness. The grey matter was distinctly red and the branches of the anterior spinal artery and the capillaries were distended. In the grey matter there were minute extravasations and the ganglion-cells were swollen, granular, and their processes could not be distinctly seen. The neuroglia constituents were swollen and hazy.

Six weeks after the onset, according to Dr. Charlewood Turner,[4] acute changes have been found in the anterior cornua. They are softened and sometimes there is hæmorrhagic infiltration, sometimes an actual cavity. The microscope shows blood, extravasated along the vessels and scattered through the grey matter, together with other cells such as are met with in myelitis. There are also granular corpuscles and other products of degeneration of the nerve-tissue. On the ventral aspect the motor nerve cells have almost entirely disappeared.

[1] *Am. Journ. of Med. Sci.*, May 1902.

[2] *Zeitschr. f. klin. Med.* 1897, vol. xxx. p. 175.

[3] *Brain*, April 1885.

[4] *Path. Soc. Trans.* vol. xxv. p. 203.

Sometimes, the disease remains confined to the anterior cornua, which are seen to be distinctly shrunken; occasionally, it extends to the adjacent white matter, and the columns of Clarke disappear; whilst the anterior nerve roots are also smaller than normal. Where the damage to the grey matter is most intense, the affected half of the cord is, even to the naked eye, smaller than the other. The degeneration extends into the peripheral nerves, and it is found that many of the fibres have perished.

The muscle fibres supplied by the affected nerves undergo granular degeneration, and the nuclei of the sheath and of the interstitial tissue increase. In many cases, the muscular fibres completely disappear and are replaced by fibrous tracts developed from the sarcolemma-sheaths and the interstitial connective tissues. Frequently, however, fibres presenting a normal appearance are seen in the midst of the degeneration-area. There is no doubt that, in the slighter cases, a partial recovery of muscle takes place, and hypertrophied muscular fibres have been seen 40 or 45 years after the occurrence of the disease. This condition is probably true hypertrophy. The appearance of some healthy muscle-fibres in the midst of degenerated tissue, and the development of such fibres into a hypertrophied condition, are facts of much importance, because they support the results of clinical experience. It is impossible to tell at any given date how much recovery will take place in an apparently hopelessly paralysed muscle, under careful treatment. We may certainly say this, the amount of recovery will always be greater than could be anticipated. It is this fact, which gives such a hopeful view to the surgical treatment of infantile paralysis.

The Bacteriology of Acute Poliomyelitis

Pasteur, Fullerton, and MacCormac have communicated to the *Lancet*[1] facts which have an important bearing on this point. They have identified a micrococcus in the spinal fluid withdrawn from patients, with symptoms of anterior poliomyelitis; and, they have succeeded in producing an ascending motor paralysis in the rabbit, after a prolonged period of incubation, by inoculating this fluid into the subdural space. On the death of the animals they demonstrated, in the cerebro-spinal fluid, a micrococcus similar to that seen in man; and, further, by similarly inoculating another rabbit with an emulsion of nerve matter and cerebro-spinal fluid from the first experimental animal, motor paralysis was reproduced after a somewhat prolonged period of incubation, and a micrococcus was found in the cerebro-spinal fluid. They failed, however, to obtain the micrococcus in culture in artificial media. The organism which was found was in the form of a diplococcus.

In their communication they referred to epidemic outbreaks of the illness which occurred in Norway during the years 1903 to 1906. Geirsvoll[2] states that 437 cases of the disease, with 69 deaths,

[1] *Lancet*, 1908, vol. i. p. 489.

[2] *Tidsskrift for den Norske Laegeforening*, No. xx. 190.

occurred in Norway during the year. Harvitz and Scheile[1] have also discussed these epidemics, which appeared not to be epidemic cerebro-spinal meningitis caused by the diplococcus intracellularis of Weichselbaum, but cases of epidemic acute anterior poliomyelitis. Geirsvoll in twelve cases obtained, in pure culture, a diplococcus or tetracoccus, which readily produced chains of four or six elements when growing in nutrient broth. These results afford the strongest presumptive evidence that he was successful in isolating a diplococcus which stood in causal relationship to the disease, which was under investigation.

Pasteur, Fullerton, and MacCormac suggest that there is not sufficient reason for assuming that acute poliomyelitis is always the result of this particular diplococcal infection. They think it is more probable that the cell changes which are seen in cases of acute poliomyelitis may be produced by other infective processes, and they refer to the experience of Trevelyan,[2] who found that, of 50 cases of infantile paralysis, which he had treated, the symptoms had followed immediately on measles in two cases, on typhoid fever in one, whilst in another case they occurred after acute rheumatism.[3]

Symptoms.—Clinically the course of the disease may be discussed under three headings: (*a*) the onset; (*b*) the paralysis; (*c*) the nature of the deformities.

(*a*) The onset varies considerably, and is frequently acute in character. The cases assume the following clinical types:—

1. A child is suddenly taken ill, and the symptoms are those of febricula, with pains in the head and back, and perhaps diarrhœa. The temperature varies from 99° to 102°. The patient is restless and perspires, and paralysis supervenes after three to ten days.

2. The child is irritable and out of sorts and is put to bed. During the night it is restless, and in the morning it is found paralysed. Apart from these symptoms the patient is well.

3. A child is suddenly seized with vomiting and convulsions, and symptoms of severe cerebral disturbance. The convulsions may last a short time, they may persist for many hours, or pass off and then recur.

(*b*) When the acute symptoms subside, paralysis is noted. It may affect any muscle, a group of muscles, or number of groups. As a rule there is no warning of the attack; sometimes disinclination to walk or stand has been noted for some days,

[1] *Jour. of Amer. Med. Assoc.* vol. xlix., 1907; also *Pathologisch-anatomische Untersuchungen über akute Poliomyelitis und verwandte Krankheiten von den Epidemien in Norwegen*, 1903-1906.

[2] *British Jour. of Children's Diseases*, April 1906; also Vipond, "Etiology of Poliomyelitis," *Brit. Med. Jour.*, March 18, 1911, p. 612.

[3] The most recent views are summed up in a note at the end of this chapter on p. 620.

previously to the attack, which may point to over-exertion of the muscles as a possible cause. Pain, of a rheumatic character, in the back and limbs is commonly an early symptom. Generally, the paralysis comes on in the night, but it has been observed to come on quietly in the daytime.

In adults, there is sometimes a sleepy and semi-stupid condition before the onset, and occasionally such symptoms as diplopia,[1] giddiness, or very occasionally delirium, are noted at the beginning. Meningitic symptoms are rare, yet they occur occasionally in the sporadic forms. The incidence of pain varies considerably. Frequently there is none; at times, however, it is very severe, and there is much hyperæsthesia. It is probably due to neuritis and to meningeal irritation.

Fig. 325.—Severe Infantile Paralysis of left lower extremity with genu recurvatum and talipes varus (Mary D., aged 16 years).

Paralysis is rapidly developed, and reaches its maximum within a few hours or a day or two after the onset of the attack. It remains stationary for from two to six weeks, and then improvement generally begins, at first rapidly, and then more slowly. After six months have passed, further spontaneous improvement is not to be expected.

[1] For information on this subject, see "the Oculo-Motor type of Polio-encephalitis," by Sydney Stephenson, *Brit. Journ. Children's Diseases*, vol. viii., April 1911, pp. 145-151. That writer concludes: "1. There is a particular type of paralytic strabismus in children which is due to polio-encephalitis. 2. It is most frequent in children, under one year of age. 3. It is associated comparatively seldom with other symptoms, indicative of a cerebral disorder. 4. Zymotic diseases appear to be important factors in its causation. 5. Although the external muscles of the eyeball may be affected, yet in three-fourths of the cases the external rectus muscle alone is involved. 6. The common form of encephalic strabismus is very apt to be confused with the ordinary form of concomitant convergent strabismus."

And, when the muscles have lost their excitability to the faradic current they generally remain permanently paralysed. There can be no doubt that, in rare cases, improvement begins immediately after the attack, and the patient recovers completely, for, we often see a completely paralysed limb, particularly the upper, recover entirely.

A rare and distressing symptom in the early stages is interference with the bladder; either retention or incontinence of urine sets in; fortunately, it disappears in a few days or weeks, so that the sphincters are seldom permanently involved. Except in the epidemic cases the cranial nerves are seldom involved, and very rarely is swallowing impaired.

The effects of the lesion are seen in (1) loss of muscular power; (2) lowering of the temperature of the limb; (3) atrophy of the limbs, with partial arrest of the growth of the bones.[1] Sometimes, lengthening occurs[2]; and, we have recorded two cases. In one instance the paralysed limb was $\frac{3}{4}$ inch, and in another it was 1 inch longer. (4) Alteration of the reflexes. (5) Sensation is modified in about one in fifty cases. In them the inflammation in the lumbar region is so intense as to impair temporarily all the conducting functions of the cord.

Muscular Paralysis.—Anterior poliomyelitis is an irregular lesion of the cord, in the sense that it involves the nerve-cells of the anterior cornua in a more or less indiscriminate manner. Thus, we find that groups of muscles are involved, one muscle in a group, or only a few fibres in a muscle. Happily the early loss of power is far more extensive and severe than the residual loss, but, generally some paresis or paralysis and atrophy remain. The recovery of power is noted first in those parts which were affected last, and then gradually spreads, until it is possible to determine at the end of two or three months the extent of the resulting disability. Muscles which are likely to become permanently paralysed are toneless and flaccid from the first and rapidly waste. The nerves and muscles no longer contract to faradism, the motor nerves will not respond to the constant current, whilst the muscles show the reaction of degeneration.[3] As a rule the paralysis is more marked in the legs than in the arms. In the upper extremity the

[1] Gowers and Taylor, *ibid.* p. 404; also Sir W. R. Gowers, "Some aspects of Poliomyelitis," *Brit. Med. Jour.*, Feb. 3, 1910, p. 305.

[2] Tubby and Jones, *Surgery of Paralyses*, p. 28.

[3] Cf. Gowers and Taylor, *Diseases of the Nervous System*, 3rd ed. vol. i. pp. 31, 32, 71, 393, 403.

deltoid is the muscle most frequently affected, and the supra- and infra-spinatus, the biceps and supinators, are usually paralysed concurrently. The extensors of the hand are more often affected than the flexors. Sometimes the flexors and extensors of the forearm have lost their power, whilst the flexors and extensors of the fingers escape. Occasionally, individual muscles are affected, such as the serratus magnus (Fig. 326) or the rhomboidei. A careful muscular analysis of the upper extremity is of great importance from a surgical point of view, because by judiciously selected measures it is possible to render stable a paralysed proximal segment, and so obtain steadiness

FIG. 326.

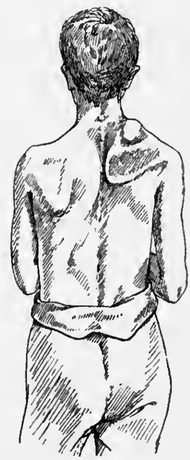


FIG. 327.

Two figures illustrating Paralysis of the lower part of the Trapezius and of the Serratus Magnus, due to acute anterior poliomyelitis (H. H., aged 11 years).

of movement and directive power in the distal segment. Thus, paralysis of the muscles about the shoulder renders the limb almost useless. If, however, we fix the shoulder-joint, we give the limb a central point of stability, upon which the distal non-paralysed segments can work, and carry out definite and purposeful movements.

In the leg, the peronei are most frequently affected, then the extensors of the toes, the quadriceps, and the tibiales. The hamstrings and calf muscles are about equally affected. The muscles which most frequently escape are the sartorius and the ilio-psoas. Advantage is taken of the escape of these last-named muscles in the surgical treatment of the affection (p. 641). The muscles of one side of the spine are often weaker than those of the other and give rise to a most obstinate form of scoliosis (Figs. 328, 329). When the abdominal muscles are badly implicated, an extreme degree of lordosis is seen.

Fig. 328.—Posterior view of severe Kypho-scoliosis, due to anterior poliomyelitis.

It is, however, impossible to classify precisely all the varieties of the affection. We can only speak of the paralysis in general terms.

The temperature of the limb rapidly falls. It is always lower than its fellow; it is often bluish, and, when pressure is applied to the surface, the blood returns very slowly. Chilblains in the winter are a source of great trouble, and, if ulcers form, they are slow to heal and very painful. Bedsores are almost unknown. It is curious to note that paralysed limbs heal up extremely well after operation, and certainly do not seem so subject to septic infection as healthy tissues.

Fig. 329.—Lateral view of the same patient as in previous figure.

Atrophy is a marked feature, and is often observable a few weeks after the onset. The wasting is due, not to disuse, but to loss of the governing influence of the nerve-cells. Retardation of the growth of the bones is usual; and it is greater, the younger the patient is, at the time of onset of the disease. If a segment of the limb is affected, the bone or bones of that part suffer most in growth. Sometimes, a gradual elongation of the bones occurs, especially in the lower extremity; and this is due to the fact that in pendent limbs the epiphyses undergo distraction instead of compression. In this connection the occurrence of coxa valga or abnormal straightness of the neck of the femur should be noted (Vol. I. p. 614). The

FIG. 330.—Dislocation of the Left Hip, the result of Infantile Paralysis. In this position the head of the left femur is in place; but, on abduction it slips out (Bradford and Lovett).

FIG. 331.—The same case as in Fig. 330; the hip is now dislocated.

affected bones are also less massive than normal, their angles are rounded, the cortical substance is thinner, and the Haversian canals smaller than in healthy bones.

Affections of the Joints.—Effusion and swelling into one of the joints, usually the ankle, occurs in occasional cases. The condition is an arthropathy, comparable to that which is seen in tabes dorsalis, and is very persistent (cf. Vol. II. p. 765). Paralytic dislocations or subluxations are often met with, and are due to loss of tension of the muscles. At the shoulder, wasting of the deltoid is often accompanied by subluxation of the humerus; at the hip, the head of the femur is sometimes unstable; and when the distribution of the paralysis of muscle around it is unequal, the bone may be gradually dislocated by the unopposed muscles (Figs. 330, 331). At the knee, the patella is sometimes dislocated outwards, owing to paralysis of the extensor.

Reflex action disappears in the region of the affected muscles. The skin-reflexes are at first lost where there is weakness, but they return soon after recovery of power in the less affected parts. If, however, there is persistent paralysis, the skin-reflex remains absent. The deep reflexes are more profoundly affected, and no knee-jerk can be obtained even if the extensors of the knees are affected but slightly.

Sensation is rarely lost; nevertheless, anæsthesia is met with in many of the epidemic and in some of the sporadic cases. When sensation is lost, incontinence of urine may be present.

To sum up. By the effects of thrombosis and cutting off the blood-supply, certain of the cells in the anterior horns are destroyed, and the muscle-fibres, which they govern, remain permanently paralysed. Other cells in the immediate neighbourhood suffer from pressure, which arises from œdema in the neighbourhood. If it passes off rapidly, these cells recover, and the temporary paralysis in the muscle also subsides. Clinically, this corresponds to the stage of partial recovery. Sometimes, however, it happens that the congestive œdema is such as to strangle the cells, both they and the muscle fibres becoming inert.

We may therefore now recognise four phases in the symptoms [1] of anterior poliomyelitis.

1. The stage of onset, when the first symptoms of paralysis appear, and its area may extend slowly, or its extreme limit be reached at once. Generally, the original paralysis is greater than that which persists, and the subsidence is due to the gradual absorption of the œdema and the disappearance of the inflammatory cell-exudation about the local myelitis. The duration of this first stage may be from one to seven days; constitutional symptoms are marked during this period.

2. The period of quiescence lasting from one to four weeks.

[1] In this connection a very full review is given on p. 578, the *Amer. Journ. Orth. Surg.* vol. vii. No. 4, May 1910, entitled, "Symptomatology of Poliomyelitis Anterior Acuta."

The constitutional symptoms have ceased and the paralysis remains.

3. The stage of partial recovery, lasting one to six months. During this period *deformity* in the paralysed parts appears.

My friend and colleague, Mr. F. R. Fisher, in a thoughtful paper entitled, "The Contracted Muscles of Infantile Paralysis" (*Lancet*, August 26, 1905), discusses many interesting points in connection with deformities arising from this disease. He says:—"The theory usually accepted for the production of talipes is that, owing to the unbalanced state of the muscles, the stronger have been in a position of over-action, have overpowered their weaker opponents, and by gradually approximating their own points of attachment have become permanently contracted. This theory is certainly inaccurate in one respect, the contraction of the muscles precedes the drawing together of their points of attachment, the latter being not the cause, but the result of contraction, with which the shortening of the fibres is coincident. It is also extremely doubtful if a muscle will acquire from over-action a condition of permanent contraction. . . . The causes, which excite the structural changes, which constitute the condition known as 'contracted muscles,' are complex in their nature. . . . It will be agreed that the term 'contracted muscle' by no means conveys a correct idea of the muscular lesion. Contraction is a normal attribute of muscular fibre; here, we have to deal with a distinct abnormality, in the deprivation of the tissue of its inability to relax; 'intractile muscle' better defines the state of inextensibility which is the main feature of the defect (of the dorsi- and plantar-flexor muscles in a case of paralytic talipes equinus)[1] and the one upon which attention should be especially concentrated. . . . It is the most commonly occurring type, but an almost infinite variety in the behaviour of the muscles is presented in the development of paralytic deformity."

There are several striking examples given, but our space does not permit us to quote as fully as we wish, still we quote a few more points: "There is one constant feature which presents itself in every case of disturbed muscular balance, the stronger muscles always become intractile to some extent, but this is the limit of methodical procedure. . . . In theorising on the development of paralytic talipes, writers have overlooked the point that muscular intractility is as distinctly a loss of natural function as is muscular paralysis; in the one case ability to relax is reduced, and in the other, power of contraction is lowered."

Mr. Fisher then proceeds to discuss the matter from the point of view that the power to cause relaxation is as much a function of the cells of the anterior cornua, as is that of contraction. His contentions are borne out by the work of Professor C. S. Sherrington.

4. The chronic stage, which lasts an indefinite time. No further recovery, if unaided, of the paralysed muscles takes place; and the

[1] The words in brackets are the author's.

deformities, if untreated, become more pronounced. We must always distinguish deformities, directly due to the paralysis, from the secondary deformities arising from malposition, the pull of unopposed muscles, and the effect of gravity.

Prognosis.—The disease is rarely fatal except when the diaphragm and intercostal muscles are paralysed, or when a lesion is so extensive as to involve nearly the entire muscle-system.

From the point of view of usefulness in life, there are few lesions so crippling and so disastrous as anterior poliomyelitis. The extent of loss of power and the limitation of the wage-earning capacity depend upon the severity of the disorder, the part attacked, and the results of careful treatment. Happily, we are no longer content to apply electricity only. By surgical measures we can often replace movement which has been lost, and restore the main functions of the part.

As to the reactions of the affected muscles, within a day or two of the onset of the paralysis, the response of the nerves and the muscles to the faradic current steadily diminishes. In some of these structures it disappears entirely; in those less involved it remains, but is lessened. Observations on these points are most valuable for prognosis, because in those muscles, which are completely paralysed, faradic excitability is permanently lost by the second week. In the remarks on pathology it has been said that, even in an apparently hopelessly paralysed muscle, some few fibres escape, and they can be induced to react to the faradic current by passing it through a needle, thrust into the muscle substance.

Moreover, the reactions of the muscles to the constant or the galvanic current are of great importance. In normal muscle, making and breaking this current causes a contraction, and the kathodal closing contraction is always greater than the anodal closing contraction; that is, K.C.C. is greater than A.C.C. In anterior poliomyelitis not only are the extent and rapidity of the muscular contractions to the constant current lessened, but the anodal closing contraction is greater than the kathodal closing contraction; that is, A.C.C. is greater than K.C.C. This is the reaction of degeneration (R. D.).

If we were asked upon what sign we should base our prognosis as to the recovery of a muscle, we should say upon response to the faradic current. If it is found to be lost by the second week, then the muscle will remain permanently paralysed. Testing the electrical reactions requires considerable care and experience; and, in the case of children, it is always safer to conduct the tests under an anæsthetic, on account of the child's fear of the current and his inability to keep quiet.

An interesting question arises, as to whether complete recovery ever takes place in infantile paralysis? In some rare cases it undoubtedly occurs in the limbs affected; in many other cases when two or three limbs are implicated, we find that it clears up in two of the limbs, leaving one partially affected. It should be noted that complete recovery is more likely to take place in the arm than in the leg. When two or three children are affected in a family with similar symptoms, we sometimes find that one recovers completely, and the others partially. The following are examples:—

In one family, two children were attacked: one child, when seen, presented complete monoplegia, whilst the mother was certain that the other child recovered in a week and is now quite well. The second instance was that of three children in one house, affected within a few days of each other, with feverish colds. Two were brothers and the third a visitor. The ages of the children were $1\frac{1}{2}$, $2\frac{1}{2}$, and $3\frac{1}{2}$ years. The eldest child, who was six years of age when we saw him, had paralysis of the left leg with displacement of the hip, lordosis and contraction of the knee. The other two children had no weakness whatever.[1]

It is difficult to tell how far an individual case will recover loss of power, yet this may be safely said: the recovery under proper treatment exceeds all anticipation. In fact, the condition of a child at a given date is no measure of the possible or even probable improvement under steady and persevering treatment, aided by surgery.

Diagnosis.—Generally, it is quite easy to recognise the disease in the later stages; but, it is often impossible, unless an epidemic is going on, to make a diagnosis of poliomyelitis in the febrile stage. Pyrexia, pain in the limbs, and cerebral symptoms all occur very commonly in a variety of infantile disorders. When these symptoms have subsided, the case is usually clear, and the diagnosis rests upon (*a*) the sudden onset; (*b*) the rapid muscle wasting; (*c*) the reaction of degeneration; (*d*) the motor paralysis; (*e*) loss of tendon reflexes; (*f*) the vasomotor changes; (*g*) the fact that sensation is not permanently altered.

Cerebral paralysis in children begins with a sudden onset; convulsions are common, and the child is soon found to be hemiplegic.

[1] *Surgery of Paralyses*, pp. 36 and 37.

Table of Differential Diagnosis of Anterior Poliomyelitis and Cerebral Paralysis in Children

	Anterior Poliomyelitis.	*Cerebral Paralysis.*
Age	Generally in children under 6 years	Not limited to this age
Onset	Convulsions not usually present	Convulsions usually present, often uni-lateral, and sometimes starting locally
Tendon reflexes . .	Generally lost . .	Reflexes normal or increased
Electrical reaction .	Diminution or loss of faradic irritability and development of R.D.	Response to the galvanic and faradic currents is normal or increased. No. R.D.
Character of paralysis .	Monoplegia or paraplegia, rarely hemiplegia. No spasm present	Generally hemiplegia, sometimes paraplegia or diplegia. Spasm usually present
Nutrition . . .	Marked wasting of the affected part	Wasting not so complete
Mental impairment .	Absent . . .	Often follows

To this table we may add that, in cerebral paralysis, facial palsy and strabismus are often present. However, in the epidemic form of anterior poliomyelitis, but not in the sporadic facial form, palsy has been observed.

Transverse myelitis is very common in children, and the affection is bi-lateral. Sensation, as well as motion, is lost, and the reflexes are at first increased. In an old-standing case of anterior poliomyelitis, especially when limited in distribution, difficulty may arise in distinguishing it from the following conditions :—Thus, Ballard[1] has pointed out that in epidemic cerebro-spinal meningitis a paralytic condition, much like that in anterior poliomyelitis, has been observed. In the former affection, pain and tenderness of muscles persist longer, and there is some spastic contraction of the muscles in the early stages, which diminishes later. The knee-jerk in some cases may be absent entirely.

All chronic lesions of the spinal cord are distinguished from anterior poliomyelitis by the history of their onset. Progressive muscular atrophy is extremely rare in children, except, perhaps, that form known as peroneal paralysis, the onset of which is very gradual,

[1] *Boston Med. and Surg. Jour.*, 1899, vol. i. p. 159.

and no reaction of degeneration is present, so long as any muscle substance remains, nor are the reflexes lost till then.

Pseudo-hypertrophic paralysis ought not to be confused with infantile paralysis. The special distribution of the former, and the fact that the pectoralis major in its lower half, the infra-spinatus, and teres minor are atrophied early, whilst hypertrophy of the muscles of the legs is increasing, are distinguishing points. There is no sudden electrical change, and the peculiar gait and family history are distinctive.

Diphtheritic paralysis, when it affects the legs, may cause considerable difficulty in diagnosis. In this disease the palate, fauces, and the ocular muscles are usually implicated early. No reaction of degeneration is present, and the muscles do not waste rapidly.

Peripheral nerve lesions arising from trauma, tight bandaging, or difficulty at birth, may be mistaken for anterior poliomyelitis, because the electrical reactions are the same as in infantile paralysis. Sensation, however, is affected, and the distribution of the paralysis follows the course of a single nerve-trunk or one of its branches. The history of the onset should be carefully inquired into.

It is impossible to go at length into the distinctions between infantile paralysis and all the disorders which have been confused with it. Many of the errors are the result of imperfect knowledge or of cursory examination. Thus, any and every cause which, on account of pain, interferes with the movement of the limbs in young children has been cited. Hip-joint disease, syphilitic pseudo-paralysis, the weakness arising at the onset of severe rickets, so-called scurvy rickets, congenital dislocation of the hip, have all been mistaken for anterior poliomyelitis.

The multiple neuritis, due to infectious diseases and metallic poisoning, should be borne in mind; however, sensation is interfered with and hyperæsthesia is often present.

Treatment.—The treatment of anterior poliomyelitis resolves itself into:—

(*a*) The therapeutics of the acute stage.

(*b* and *c*) Application of remedies during the stationary period and that of partial recovery. They comprise warmth to the affected parts, massage, the use of the electrical current, the prevention of deformities, and the functional use, in a normal direction, of those muscles which are recovering.

(*d*) In the final stages, treatment of the effects of the paralysis, particularly of deformities. Massage and warmth are of continued service, although electricity is of much less value now. It is at this stage that surgical advice and help are required.

Surgical Treatment.—Surgeons have the following means at their disposal :—

Mechanical measures, such as the use of apparatus, designed for supporting and steadying the affected limbs, overcoming the contractions, and assisting the utilisation, in the right directions, of the power remaining in the part: in effect, properly directed functional use.

Operative measures including tenotomy, the lengthening of contracted tendons and the shortening of weak ones, and the taking up of the "slack" in the soft tissues on the paralysed side of the limb.

Tendon transplantation and muscle transference.

Fixation of joints by arthrodesis and steadying them by artificial ligaments.

Osteotomy.

Nerve-transplantation and nerve-grafting.

Treatment during (*a*) **the Stage of Onset.**—If the disorder is recognised, and this is likely to be the case when more than one child is affected in the house, active measures must be taken at once. The child must be nursed on its side or in the prone position so as to prevent stasis of the veins in the spinal region. Counter-irritation by iodine should be used over the spine, but blisters are best avoided. Vaso-constrictors, such as ergot, and sedatives, such as bromide of potash and soda, are useful. Purging is also called for, not only to clear out the intestinal canal, but also to lessen the congestion in the affected spinal area. After the purge has acted, intestinal disinfectants are to be given, and the doses should be pushed. Salol gr. v, or sulphocarbolate of soda, gr. xv, t.d.s. unless urinary symptoms are produced, is prescribed.

Belladonna, or belladonna combined with ergot, has been thought by some to control and arrest the rapid progress of the disease. For two or three weeks after the subsidence of the symptoms the patient should be kept perfectly at rest, especially when there is persistent tenderness in the limbs.[1]

(*b and c*) **Second and Third Stages.**—That is, a stationary stage lasting about one month, followed by the stage of partial recovery,

[1] Lange, *Amer. Jour. Orth. Surg.* vol. viii. No. 4, August 1910, remarks that, "We have found children, ill with poliomyelitis and suffering severe pain, become free from pain, on the application of a plaster of Paris jacket, which held the spinal column still and at rest." Lange thinks that, "at present we can rely less on internal remedies (in the acute stage) than on orthopedic fixation of the spinal column."

which extends to a further six months. During the stationary stage it is probable that, whilst certain nerve-cells are completely destroyed, the activity of others is merely checked by the pressure of inflammatory products. As the pressure subsides, partial recovery takes place; and here we may quote Gowers and Taylor.[1] "At the end of six months all possible recovery (in the central nervous system) is nearly complete; and, certainly in a year, the lesion has become a cicatrix, and further improvement may be by the slow growth of a muscle, which has recovered under the stimulus of use. This process of slow improvement (in the function of the affected parts), as the result of use, will go on for years." The object of all forms of treatment, in the second and third stages, is to ensure that the ultimate amount of muscular power possessed by the patient is as great as possible. There is, as we have remarked, a natural tendency to recover which must be encouraged in every possible way.

The question then arises, How can the desired object be effected? We must (1) maintain the nutrition of the muscles to the utmost degree possible; (2) retain the affected limb in a normal position, and guard against stretching of the ligaments, muscles, and tendons of the paralysed parts; and (3) prevent contraction of normal and unopposed or partially unopposed muscles.

Maintenance of Nutrition of the Muscles.—The agents we have at our command are—

Dry warmth and massage.

Electrical stimulation of muscles.

Systematic functional use of the muscles.

Relaxation of tension, and the prevention of stretching the muscles.

Of all the measures, *massage* is undoubtedly the best when the initial irritation has subsided. Skilled massage is undoubtedly better than domestic rubbing; and an accurate knowledge of the position and direction of the affected muscles and their actions is essential to obtain the best possible results. An intelligent person can, in a few lessons, learn all that is required. The value of warmth to the part cannot be over-estimated. In the winter the paralysed limb should be protected by very thick stockings, and the boots lined with lamb's-wool. The hips and thighs should be thoroughly well covered with flannel garments. Before massaging the part, the affected limb is thoroughly warmed for half an hour or an hour before a fire. A good plan is to place the child in

[1] Gowers and Taylor, *Diseases of the Nervous System*, 3rd ed. vol. i. p. 424.

front of a fire or stove with the legs thrust through a hole in a sheet of pasteboard, which serves as a screen to the rest of the body. Heat from a hot-air oven, or that from an electric radiator, is useful. Any improvement in the circulation must be followed by increase in the nutrition of the muscles, therefore dry warmth and massage should always be combined. We have found much benefit from the use of the muscle-beater (Fig. 332).[1] It consists of a rubber ball, fixed to a flexible steel rod in a handle. The affected muscle should be gently beaten with it, provided that there is no tenderness. Instead of manual massage, mechanical stimulation by vibrators and other specially constructed appliances can be employed.[2]

Fig. 332.—A Muscle-beater (R. Jones).

Electricity is of course powerless when nerve-cells, nerve-fibres, and muscles are destroyed. However, when the last named are only partially deprived of the influences normally exerted through the nerves, electricity is of the greatest value in maintaining the sensitiveness of the muscles to stimuli, until recovery, or it may be regeneration has taken place in the nerve-fibres. If the muscle is left untreated, some of its fibres during this critical period undergo such degeneration that, when recovery of the nerve elements takes place, the contractile tissues are unable to respond to voluntary stimuli.

The faradic current is of service, only when the nerve-fibres are not degenerated. For muscles the constant current is more useful. The anode is placed over the upper part of the muscle, or over the spot where its nerve enters it. There is no advantage in placing it over the spine, since the current cannot influence the destroyed nerve-cells in the spine, and it is doubtful if the current ever reaches the spinal cord at all, when so used. Further, by reason of the greater area over which it spreads, it causes more alarm and inconvenience than are desirable. The negative electrode is used for repeatedly stroking the muscles. It consists of a sponge or conductor covered with water-holding material, well wetted with saline solution. Between each stroke the negative electrode is lifted from the skin. This breaks the current, and, when it is again applied to the skin, the current is made; and at each make and break the muscle is seen to contract. The number of cells used should not be such as

[1] Tubby and Jones, *Surgery of Paralyses*, p. 48.

[2] Lange, *loc. sup. cit.*, warns us especially against rough, hard massage, and above all against a deep, firm, stroking massage, as likely to damage the partially paralysed muscle.

to distress or alarm the child. Too often, on the first application, an unnecessarily strong current is used, and the child does not get over the alarm. It is often a good plan to commence without any current; applying the sponge in the way directed, so as to familiarise the child with the apparatus; then one or two cells may be used, and more later, if they can be borne. The time for beginning electrical treatment is four weeks after the onset of paralysis. The application should be made once or twice daily, and be preceded by massage.

Active muscular effort or functional use is of great service and is a distinct tonic to the muscles; the partly paralysed muscles, however, should not be overtaxed or over-stretched. It is quite certain that the recovery of weakened and partially paralysed muscles is more hindered by *over-stretching* than by anything else. The weakened part should be assisted in its movement by the hand of the attendant. It is not necessary to formulate a series of exercises, and one example will suffice. When there is drop-foot or paralysis of the dorsi-flexors, the attendant may gently press his hand against the sole and encourage the patient to dorsiflex the foot. With each repetition of the exercise the dorsi-flexors will be found to accomplish more and more. In fact, the object of these exercises is so to assist those muscles which, if they have any power left, will enable them to use it in the normal directions. Some mechanical support is often necessary to help the limb in carrying out movements, which are most likely to call into use the affected structures. Thus, for instance, in talipes equinus a toe-elevating spring of moderate power is generally applied.

The maintenance of the affected limb in a normal position and the avoidance of stretching the ligaments, muscles, and tendons of the paralysed parts, together with the contraction of the normal and unopposed or partly unopposed muscles, may be considered together. The simpler the apparatus employed the better. In practice we find splints made of malleable iron of various sizes, and properly fitted, of the greatest service. They can be bent or twisted so as to fit any part, and the angle can be altered day by day so as to oppose muscles which are becoming contracted (Figs. 333-339).

Immediately it is evident that a group of muscles is weakened, the part must be supported in such a way that no stretching takes place. Our view is that recovery is always hindered and even entirely prevented in a stretched muscle; whereas, when it is relaxed the reverse is the case. *Therefore, in order to obtain the maximum* *amount of recovery in an affected muscle, relax it to its fullest extent and massage it.* Elongated muscles are earliest restored to power

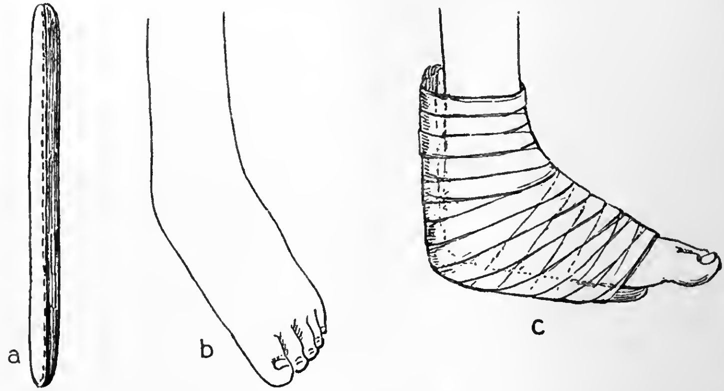


FIG. 333.—Showing the use and the application of the Malleable Iron Splint for Foot-Drop. *a*, Malleable iron splint, before bending ; *b*, dropped foot ; *c*, the splint bent to a right angle and bandaged to the foot, now at right angles ; later, the splint may be bent acutely so that the foot is dorsiflexed.

and use by maintaining them slack.[1] It is advisable to support the parts by night as well as by day, for, during sleep, the unopposed

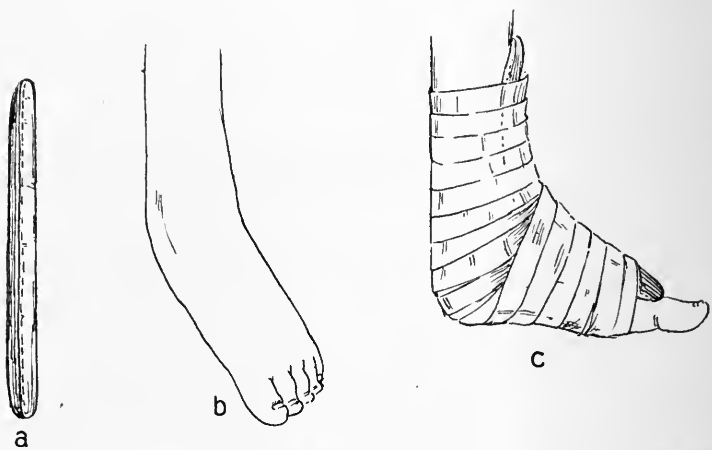


FIG. 334.—A second method of using a Malleable Iron Splint for Foot-Drop. *a*, Malleable iron splint ; *b*, dropped foot ; *c*, splint bent and applied to the foot, so that it is held at a right angle.

flexors are more likely to stretch the weak extensors than during the waking hours.

[1] Tubby and Jones, *Surgery of Paralyses*, pp. 108 and 150.

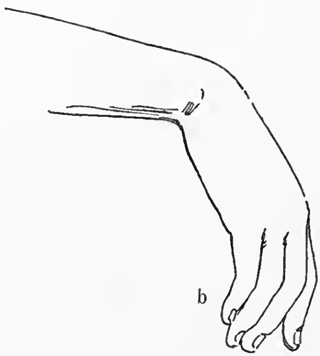


FIG. 335.

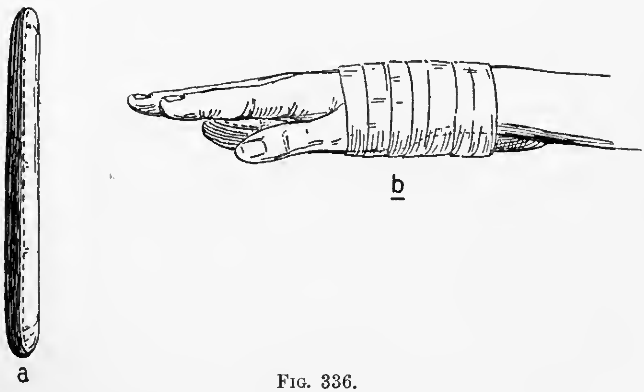


FIG. 336.

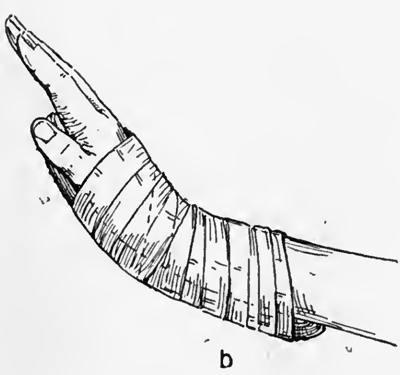


FIG. 337.

Three figures showing the method of securing gradually Hyper-extension of a Dropped Wrist. *a*, Malleable iron splint ; *b*, dropped wrist.

It is a reproach to the medical attendant, if he permit deformity to occur during the second and third stages.

(*d*) **The Chronic Stage.**—This is *par excellence* the stage of deformity. The backward condition of the surgical therapeutics of poliomyelitis is due to a serious mistake that some practitioners make, in that they fail to distinguish between the loss of power caused by destruction of motor cells and that due to muscle contracture. "And to this error may be ascribed much of the pessimistic tone which pervades literature when the treatment of infantile paralysis

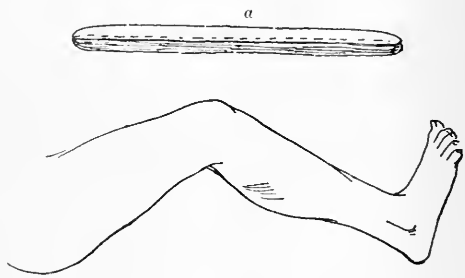


FIG. 338.

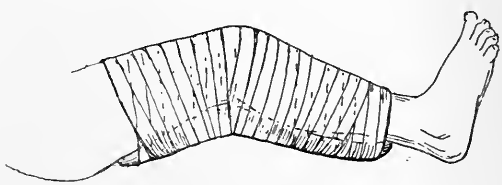


FIG. 339.

Two figures showing a method of supporting the leg, and reducing the flexion of the knee, due to weakness of the extensor cruris, by means of the Malleable Iron Splint.

is discussed." By the intelligent recognition of the differences between the disabilities due to mechanical causes and those due to central pathological changes many of the difficulties of treatment will disappear.

Now, what are the causes of deformity? They are:—

1. The first is paralysis of nerve and muscle.

2. The second is the force of gravity.

3. The unopposed action of healthy muscles and intractility of paralysed and partially paralysed muscles (Fisher). See Vol. II. p. 607.

4. Perverted functional use.

5. Vicious positions.

The effect of the force of gravity is illustrated in the case of paralysis of the anterior muscles of the leg. If it occurs before the child walks, the foot drops under the influence of gravity into the attitude of equinus. If this is allowed to persist, the posterior muscles, adapting themselves to the position, become structurally shortened; therefore, in this case the origin of the deformity is primarily due to gravity, it is secondarily increased by unopposed muscle action, and finally it is fixed by muscle contracture. That these elements are sequentially at work is proved by the fact that the deformity may be prevented by stimulating the anterior muscles daily with the constant current, and by passively stretching the plantar flexors to their extreme length.

As a rule, muscular action and gravity act concurrently, yet such is not always the case. They may be in opposition, as in a case of talipes calcaneus, where the calf muscles are affected. If the child sits with its feet off the ground they are pointed and in a position of equinus, which is due to gravity; whereas, when he stands and attempts to walk, the heel drops, and the calcaneus deformity is at once evident in walking, owing to the action of the dorsi-flexors.

Perverted functional use as a cause of deformity is illustrated by paralytic talipes valgus, where the supinator muscles of the foot (those muscles whose tendons pass behind the internal malleolus) are partially affected. When the patient sits, the deformity is not evident; but when he stands, the foot is valgoid, partly owing to the weakened supinators, and partly to the fact of the body-weight falling on the unbalanced foot. As Whitman remarks: "Thus it is that the deformity develops far more rapidly when a fair amount of muscle power remains, than when it is completely destroyed."

The effects of vicious position are best seen in those parts which are totally paralysed, and arise from the structural shortening of ligaments, fasciæ, and atrophied muscles. In the foot the most usual position is talipes equinus, where gravity is the first factor at work in producing the deformity, and vicious position the second.

In addition to the five factors above mentioned we must also mention one other, namely, simple weakness. Its effects are seen when a joint, such as the hip, becomes subluxated, and the leg is held in an abnormal position owing to the contraction of a few unopposed muscles. For example, in those cases of paralysis about the hip-joint where the tensor vaginæ femoris, the sartorius, and the adductors alone remain intact, the thigh is held flexed and inverted, the head of the bone is displaced backward and upward, and the deformity is very considerable.

We see, therefore, that the onset of the deformity is due to many causes, and they should be carefully recognised and discriminated, the relative effect of each in an individual case being correctly estimated. Moreover, there is no doubt that, with due appreciation of all the points concerned, an immense amount of benefit can be conferred by the use of appropriate methods upon sufferers from infantile paralysis. We know by our own experience that patients, who were deemed hopeless cripples, have been enabled to walk; and in many instances, where segments of the upper extremities have been paralysed, the limb can be so fortified as to be of the greatest use to the patient.

We pass on in the next chapter to discuss the surgical means at our disposal.

Note on Most Recent Views of Pathology of Poliomyelitis

F. E. Batten [1] sums up the present-day conception of the disease thus:—Poliomyelitis is an infective disease, as proved by the work of several observers. It is transmissible from man to monkeys and from monkeys to man. The virus will pass through the finest filter, and the organism has not yet been stained, nor has it been seen under the highest powers of the microscope. The virus may be obtained from the nasal mucus of a monkey, who has suffered from the disease, six months after infection. It is still active, and is strikingly similar to that of rabies. The disease has also been epidemic in England and abroad, and should be treated by isolation. Its incubation is less than six days, and the period of isolation should not be less than three weeks. It is believed that urotropin may prevent infection and diminish the virulence of, if not destroy, the virus.

[1] *Brit. Med. Jour.*, Sept. 2, 1911.

CHAPTER II

SURGICAL TREATMENT OF DEFORMITIES ARISING FROM INFANTILE PARALYSIS

Surgical Treatment by Mechanical Means—Tenotomy—Shortening of Tendons and Relaxed Ligaments—Insertion of Artificial Ligaments—Tendon Transplantation—Tendon Grafting and Muscle Transference—Arthrodesis—Osteotomy—Nerve-Transference and -Grafting.

THE surgical measures which are employed in the treatment of deformity from anterior poliomyelitis are:—

1. Mechanical measures.
2. Tenotomy.
3. Shortening relaxed tendons and ligaments, combined with exsection of soft tissues.
4. The insertion of artificial ligaments.
5. Tendon transference, tendon grafting, and muscle transference.
6. Arthrodesis.
7. Osteotomy.
8. Nerve-transference and -grafting.

The recent progress of the surgical treatment of paralytic deformities has been impelled by the limitation of medical treatment as expressed by the words massage, electricity, and improvement of the general nutrition. It has been realised how ineffectual such measures are to produce satisfactory results. Therefore, workers in this field have perforce asked, What can surgery do? It is our object to show what operative surgery is doing, and to indicate the lines of future progress.

MECHANICAL TREATMENT

The objects of the mechanical treatment of infantile paralysis are—To support and protect the limb in such a way that the affected muscles may act to the best advantage and the joints be controlled. This means, in effect, the prevention of deformity from contraction and gravity, and the maintenance of the functions and nutrition of the limb to the greatest possible extent, by enabling it to be used in more or less normal directions. We can restore muscular balance

FIG. 340.

FIG. 341.

Two figures showing the utility of apparatus in severe Infantile Paralysis. In the left-hand figure, the patient can proceed by the aid of crutches only; in the right-hand figure, he has been enabled to stand and walk without crutches.

and improve locomotion. We can also overcome deformities and prevent their re-appearance by stretching some shortened tissues and shortening relaxed tissues. Finally, we can support flaccid limbs, and hold them in such a position that they become partially useful.

Mechanical treatment is called for, when the legs are unable to support the body; and when deformities, not evident during sitting, become pronounced on standing. A familiar instance of the latter phase of deformity is paralytic talipes valgus.

It is certain that many paralytic deformities can be counteracted by mechanical arrangements: and patients, hitherto helpless, can be enabled to walk. This is particularly so in those instances of almost total paralysis of the lower extremities, where the ilio-psoas, alone of all the muscles, has escaped in one or both limbs. If this has retained power, there should be no hesitation in promising the patients that, by the application of suitable apparatus, they can be enabled to walk. Several sufferers have come to us, absolutely incapable of movement, with the hips, knees, and feet twisted in various directions by contractures. However, the ilio-psoas muscles were found to be functionally active. After other contracted muscles and tendons were divided and the limbs straightened, the patients were set upon their feet by the aid of apparatus; and some have eventually walked as far as two miles—of course, with the knees rigid and the ankles stiffened. Even with one ilio-psoas intact, similar satisfactory results have followed. It is striking to observe how other muscles, hitherto thought to be hopelessly paralysed, became partially active, and the nutrition and circumference of the limbs increased.

The varieties of apparatus are many, and it is not possible to specify them here. They are, however, practically of two classes. The simple forms, of which the best type is the malleable iron splint, bent so as to fit the part; and the complex mechanical supports, the application of which depends upon the experience of the surgeon. So far as possible, the type of apparatus appropriate to each condition of paralysis will be indicated presently.

Tenotomy

Tenotomy proved to be a distinct advance on the mechanical methods, because by its means deformities, which were previously intractable, could be rectified. Its limits of usefulness are, however, circumscribed.

To take again the example of paralytic talipes valgus, if the contracted peronei tendons are divided, the foot can be put into a correct position; it must, however, be held there by apparatus. The problem of the treatment of the deformity has not been radically attacked. It is true that the tension of the healthy muscles, pulling upon their opponents, has been lessened by tenotomy, and partial recovery of power in the latter has been promoted. Nevertheless, there has been no immediate and direct addition to their activity, and the joint, on which they should act, has not been rendered one whit more stable. In effect, all that has been accomplished is to obviate some of the mechanical effects arising from the loss of power of one group of muscles, due to destruction of the central nerve-cells controlling them.

It is necessary to do more than this. The problems are to distribute what power remains around the joint, to place the muscles in as perfect a balance as possible, and to render the part more stable.

Tenotomy, however, is valuable, not only in helping to overcome contractions, but also in obviating that stretching of the weakened opponents, so detrimental to their nutrition. If the latter are constantly on the stretch, they rarely show signs of recovery. If, however, the pull on muscles, apparently paralysed, is relaxed, whether it be effected by mechanical arrangements or by tenotomy, movements soon commence, faint at first, yet slowly increasing.

These considerations have convinced many surgeons that the operation of tenotomy is not all-sufficient, and more must be done. The lower limb should be made firmer and better adapted to support the body-weight. If sufficient muscular power is left, it must be re-distributed around the joints, so as to obtain as complete a balance of power as is possible under the circumstances. In the upper limb, paralysis of a proximal segment renders healthy distal parts nearly useless. By steadying and fixing, for example, a flail shoulder-joint, the healthy muscles acting on the elbow, wrist, and fingers are rendered much more serviceable.

Shortening of Relaxed Tendons and Ligaments, Combined with Exsection of Soft Tissues

The shortening of relaxed tendons and ligaments—taking up the "slack" so to speak—may be regarded merely as an adjunct to procedures such as tendon transplantation and arthrodesis. It is well known, however, that if we pleat the tendon of a paralysed muscle, with the object of shortening it, the result is not permanent. When strain is thrown upon the muscle, it lengthens, as has often been demonstrated in the treatment of paralytic talipes calcaneus.

The tendo Achillis has been shortened by pleating or exsecting a part of it, but the deformity recurs. The shortening of ligaments is more satisfactory, because we are dealing with inelastic structures, and they do not again yield.

Mr. Jones has advocated, and practised largely, exsection of a lozenge-shaped portion of skin and subcutaneous tissues on the weak or paralysed side of the distorted joint. When the edges of the skin incision are brought together, an additional bulwark against the recurrence of deformity is erected. However, we await from him details as to the subsequent stretching of the scar or otherwise.

The Insertion of Artificial Ligaments

With the object of strengthening a flail-like or weak joint, artificial ligaments of mercurialised silk may be inserted. My experience is a fairly extensive one. I have used it in a case of dislocation backwards of the head of the radius, causing stretching of the posterior interosseous nerve and paralysis of the extensors of the hand. The head of the radius was replaced, and an artificial orbicular ligament put in. The child gradually regained power in the extensors. I have also placed strands of silk between the tibia, fibula, astragalus, and os calcis for talipes calcaneus, and found that the falling of the heel was prevented. E. H. Bradford and Robert Soutter [1] report a case of artificial ligaments, operated on, four years previously, for foot-drop. The case shows the permanency of the strength of the ligament (presumably the anterior of the ankle) [2] and its ability to check foot-drop. " A child, of 8 years of age, had also developed, to a surprising extent, power and ability to raise the front of the foot by the development of the extensor muscles of the foot, which were supposed to be paralysed. The strength of properly inserted artificial ligaments and the restoration of function in transferred muscles of the toes is well illustrated in a man of 23 years, one year after the operation, where not only was foot-drop prevented, but some restoration of function furnished " (Bradford and Soutter).

Artificial ligaments are also of great service as adjuncts to tendon-transplantation and arthrodesis. In the former " they serve to protect the transplanted muscles from undue strain during the period when their condition needs to be nursed."

[1] *Amer. Jour. Orth. Surg.* vol. vi. No. 2, Nov. 1908, p. 199.

[2] The words in brackets are the author's.

Tendon Transference, Tendon-Grafting, and Muscle Transference

Definitions.—By tendon-transplantation is meant the reinforcing of a paralysed muscle by attaching to its tendon either a whole or a part of the tendon of a healthy muscle.

By muscle-transplantation is meant the transference of a muscle or a portion of it in such a way as to alter the point of insertion.[1]

The *history* of tendon-grafting dates from 1882, when Nicoladoni[2] implanted the central ends of the severed peronei into the tendo Achillis. The immediate results of Nicoladoni's operation were promising, yet Maydl[3] states that the anastomosis finally separated, and all the benefits of the operation were forfeited. Tendon-transplantation was revived by Drobnik in 1892,[4] and simultaneously and independently by Parrish of New York[5] in a modified form. Drobnik introduced tendon-splitting, inserting a re-inforcing strip from a normal muscle into a paralysed tendon. Since 1892, many surgeons have worked in the same field. In this country Sir F. Eve, R. Jones, Montgomery, E. M. Little, the author, and others; in America, Bradford and Lovett, Whitman, Goldthwait, Waterman, Dane and Townsend; in Germany, Hoffa, Vulpius, and Lange, and in France, Kirmisson and other surgeons.

A full review of the literature of the subject up to 1904 will be found in *Chirurgie orthopédique* by Berger and Banzet on pp. 250 and 251, and in the works of Hoffa,[6] Vulpius,[7] Lange,[8] and Codivilla.[9]

The forms of tendon-transplantation may be classified, so far as the insertion of the transferred tendon is concerned, as the intermediate and the immediate.

Intermediate Methods. — The intermediate procedure comprises several forms:—

(*a*) 1. The tendon of a healthy muscle is completely cut across near its peripheral extremity, and its central end is inserted directly into the paralysed tendon (4, Fig. 342). The action of the distal end of the active tendon is, however, completely suppressed.

[1] Many of the remarks on this subject were incorporated in the Hunterian Oration delivered in 1906 before the Hunterian Society by the author (*Brit. Med. Jour.*, March 3, 1906).

[2] *Archiv der klin. Chir.*, 1882, iii., xxvi. s. 660.

[3] *Wiener med. Presse*, 1886, p. 882.

[4] Drobnik, *Zeitschr. für Chir.* Bd. 48, p. 470.

[5] *New York Med. Jour.*, Oct. 8, 1898.

[6] "Über die Endresultate der Sehnenplastiken," *Archiv f. klin. Chir.* S. 1, 1.

[7] *Die Sehnenüberpflanzungen*, Leipzig, 1902, and *Deut. med. Wochenschr.*, 1908, iv. 142.

[8] Joachimsthal, *Orth. Chir.*, 1904, pt. i. p. 265.

[9] *Verhandl. der D. Ges. f. orth. Chir.* ii.

2. The central end of the divided healthy tendon is attached to a strip from the distal part of the paralysed tendon (2, Fig. 342).

3. The healthy and the paralysed tendons are divided, the central end of the active one is joined to the distal end of the paralysed, and the proximal end of the paralysed is joined to the distal end of the active. Thus an attempt is made to conserve whatever power may remain in the weakened or partially paralysed muscle. This is the "complete interchange method" (3, Fig. 342). Unless, however, great care is taken to isolate the junctions by cargile membrane, matting of the tendons is likely to occur, and the operation becomes abortive.

(*b*) The paralysed tendon is cut across, and its distal end is sutured to that of a healthy muscle (5, Fig. 342). The disadvantage

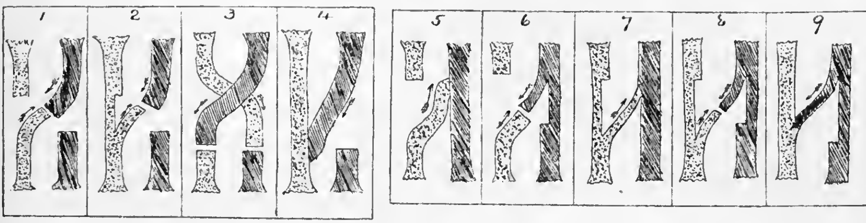


FIG. 342.

Schema (after Vulpius) to show nine methods of Tendon-Transference. The tendon of the paralysed muscle is in light shading, and that of the healthy muscle in dark shading.

of this method is that the paralysed and degenerated tendon, being no longer inextensible, gradually stretches and loses its transmitting power. Whatever power remains in the weak muscle is also completely sacrificed.

(*c*) 1. A strip is taken from the central part of a healthy tendon, and is attached directly to the undivided paralysed tendon (9, Fig. 342).

2. A strip from the central part of the healthy tendon is joined to a strip from the distal part of the paralysed tendon (8, Fig. 342). This method gives better results than others, because the continuity of the healthy tendon is not destroyed completely, and its action is fully conserved. Moreover, as the continuity of the paralysed tendon is not interrupted, if some recovery takes place later in the apparently paralysed muscle, or if any power remains in it, aid is given to the action of the re-inforcing strip from the healthy tendon.

The Immediate Method.—Lange of Munich[1] ascribes some failures, in tendon-grafting from a healthy muscle, to the subsequent stretching of the paralysed and degenerated tendon. He revived and extended direct or immediate periosteal implantation, originally essayed without success by Drobnik. Lange prolongs the tendon, when too short, by means of silk threads, and thus secures an attachment to the bone of the partially artificial tendon at the most suitable spot for effective action. The first application of the periosteal method of insertion to the upper limb was carried out by the author[2] in 1901 for spastic paralysis, independently of any knowledge of Lange's work: the pronator radii teres was separated from the radius, carried through the interosseous membrane to the back of the bone, and re-inserted on its outer side so as to assist in supination. There is no doubt that the immediate method of Lange marks a great advance over the older methods, and has rapidly displaced them. The technique will be dealt with presently.

The Objects of Tendon-Transplantation.—If one or more muscles are paralysed, the balance of the part is lost and distortion and deformity ensue. To some extent we can rectify this by mechanism. By tendon-transplantation, however, an effort is made to utilise to the best advantage the power left in the part, and an attempt is made to restore the balance. We therefore expect a partial restoration or improvement of function and the prevention of deformity. It is therefore a surgical proceeding in every way superior to tenotomy and the use of supports, although its application requires great care and discretion.

The *indications* for tendon-transplantation are—

1. To replace completely or partially paralysed muscles and groups of muscles.

2. To strengthen weakened muscles and groups of muscles, by transferring power from muscles which are too strong.

3. To alter the direction of perverted tendon action, such, for example, as exists in talipes valgus, where the foot is turned out by the over-action of the peronei; one of them, preferably the brevis, may be transferred to the inner side of the foot, so as to lessen the eversion and produce some inversion.

4. As a measure, supplementary to arthrodesis in the foot,

[1] *Münch. med. Wochenschr.* No. 10, 1898; Nos. 15 to 26, 1902; *Rep. of Cong. of Germ. Orth. Surg.* 1903; *Zeitschr. f. orth. Chir.* Bd. vii. F. 1, 1900; Bd. xii. Hefte 1 and 2.

[2] A. H. Tubby, *Brit. Med. Journ.*, Sept. 7, 1901.

stability being provided by arthrodesis at the ankle, movements of the other joints being restored by tendon-transplantation.

5. To replace tendons destroyed in the hand.

Preliminaries to Tendon-Transplantation. — It is essential that all secondary deformities should be corrected in the first place. And, it is of great importance, before deciding to operate, to study the case carefully and map out a definite plan of campaign. The functions of the muscles and their relative share or shares in the performance of a movement should be fully grasped. Codivilla has, in the case of the foot, worked this out very satisfactorily,[1] expressing his results in units up to 10, the numbers being in the order of importance, No. 1 being of the greatest.

	Dorsal Flexion.	Plantar Flexion.	Adduction.	Abduction.	Pronation.	Supination.
Tibialis anticus . . .	1	...	...	...	...	1
Extensor proprius hallucis .	3	...	...	...	...	6
Extensor longus digitorum .	2	...	...	3	3	...
Peroneus brevis . . .	...	6	...	2	2	...
Peroneus longus . . .	...	3	...	1	1	...
Gastrocnemius and soleus .	...	1	2	...	...	2
Tibialis posticus . .	...	4	1	...	...	3
Flexor longus hallucis .	...	2	3	...	...	4
Flexor longus digitorum .	...	5	4	...	...	5

In a paralysed part the electrical reaction of the muscles should be previously ascertained, movements present and lost being carefully noted, and the muscle power, remaining in the limb, registered by means of a dynamometer.

A clear conception of the relative importance of the functions of a part should exist. Thus, in the case of the foot, plantar flexion is more important than dorsal flexion, because if the former is lost the leverage of the foot in elevating and propelling the body is destroyed. Dorsal flexion is more important than abduction or adduction. Again, adduction is more important than abduction, because varus is a less disabling deformity than valgus, and is less difficult to remedy. The relative strength of the muscles of the foot and their functions has been worked out by R. Fick.[2]

[1] Whitman, *Orthopedic Surgery*, 2nd ed., p. 834.

[2] *Über die Arbeitsleistung auf die fussgelenkewirkende Muskeln*, R. Fick, Leipzig.

Dorsal Flexors of the Foot (strength reckoned in kilogrammetres).

Tibialis anticus	0·871
Extensor longus digitorum	0·280
Extensor proprius pollicis	0·155
Peroneus tertius	0·087
	1·393

Plantar Flexors.

The Calf Muscles—Soleus	3·256
Gastrocnemius	2·831
Flexor longus pollicis	0·218
Peroneus longus	0·118
Tibialis posticus	0·094
Flexor longus digitorum	0·078
Peroneus brevis	0·055
	6·650

It will be seen from this table how hopeless it is to expect the peroneus longus and brevis to take the place of muscles such as the soleus and gastrocnemius, the calf muscles being many times stronger than the evertors.

The Selection of Tendons.—In addition to the above considerations in transplanting tendons, the object should be not only to replace loss of function, but also to obviate deformity; thus, the functions of the tibialis anticus can be most readily replaced, without damage, by transferring the proximal end of the extensor proprius pollicis either into the tibialis anticus tendon, or, better still, anchoring it to the periosteum of the scaphoid and the internal cuneiform bones. The slip of the extensor brevis digitorum to the great toe will supply the required extension to that digit. Before the operation is undertaken, we should satisfy ourselves that strong and healthy muscles are within convenient and suitable distance of the paralysed ones.

The second object of the operation—to reduce the deformity of eversion—is accomplished by dividing the extensor longus digitorum and attaching its proximal end to the periosteum on the inner side of the foot; or, better still, by transferring the tendon of the peroneus brevis from the outer to the inner side of the foot.

Lange has pointed out how important it is to have a simple plan of procedure. Vulpius has elaborated 116 operations, of which only a few are purposeful, if we consider function as well as mere form. Lange has given a few simple procedures. Vulpius is averse to making muscles take on a new function. He painfully tries to provide each paralysed muscle with some healthy tendon by splitting and transference, and then, as we should expect, the transplanted parts fail to act independently. In fact, in some cases, the transplanted part, as when a portion of the tendo Achillis is transferred, becomes a mere ligament.

We give a brief outline of Lange's schemes for dealing with paralysis of the leg and foot. He regards nine muscles as being at his disposal. The schemes are briefly as follows :—

1. If not more than three muscles are paralysed, such as the tibialis anticus, the extensor proprius pollicis, and the extensor longus digitorum, we can replace the tibialis anticus by the flexor longus pollicis and the other two by one of the peronei. The peripheral end of the flexor longus pollicis can be sewn to the flexor longus digitorum, and the peripheral end of the cut peroneus to the other peroneus.

2. When four of the long foot-muscles are paralysed, then we must sacrifice the mobility of the toes. This is not very important to boot-wearing people. So that we are able to make use of five to subserve the

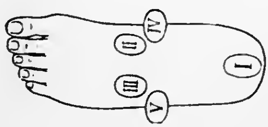


FIG. 343.

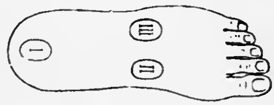


FIG. 344.

FIG. 343.—To illustrate Lange's Schema for the Utilisation in the Foot of the remaining Five Healthy Muscles and Tendons. I. Position of attachment of the chief plantar flexor. II. and III. Position of attachment of the chief dorsi-flexors. IV. Position of attachment of invertor muscle. V. Position of attachment of evertor muscle.

FIG. 344.—Lange's Schema for the Utilisation in the Foot of the remaining Three Healthy Muscles. I. Position of attachment of the chief plantar flexor. II. and III. Positions of attachment of the dorsi-flexors.

important functions. The strongest is fixed to the heel to become the plantar-flexor, and of the others two are implanted on the dorsum of the foot to become dorsi-flexors, and one on each border of the foot to an adductor and an abductor respectively (Fig. 343).

3. If only three sound muscles are left, they must be distributed so that the strongest is implanted into the heel to become a plantar flexor, and the remaining two into the dorsum to become dorsi-flexors. By putting the latter not too near the centre of the foot, they will also act to some extent as an adductor and an abductor respectively (Fig. 344).

4. If only two muscles are left, the functions to aim at are plantar- and dorsi-flexion, and we sacrifice adduction and abduction.

This planning is simple, and simplicity is essential to the surgeon who does not perform many muscle transplantations, and has not the necessary practice to ascertain the position of his muscles until they are laid bare.

An extensor should not be combined with a flexor to make a new muscle. Thus in operating upon the knee, the results are not so good if the sartorius is combined with the biceps, as when the hamstrings alone are used, because the sartorius is an extensor, and the biceps is the flexor of the knee.

Before performing the operation, we should have a clear conception of the main function of the affected segment of the limb. In the foot, stability is more important than movement. If movements are sought, plantar- and dorsal-flexion are the most important. In the hand, movements are vital, particularly fine movements. In boot-wearing people movements of the toes are of slight value, but the movements of the tarsus are exceedingly useful. Therefore tendons which go to the toes should be divided, and implanted on the tarsus to add to its mobility. At the wrist and in the hand the converse is the case; the movements of the fingers are all-important, and therefore the tendons attached to the carpus should be sacrificed in preference to those of the fingers.

Re-inforcing muscles or tendons are, as far as possible, to be taken from synergists, for the obvious reasons that they are adjacent, and the difficulty of after-education in not so great. A re-inforcing tendon should not be bent round at an angle, but carried directly to its insertion, that is, the tunnelling through the soft tissues should be direct.

In the foot, the anterior abductor muscles are to be used to make the anterior adductor and the posterior abductor to make the posterior adductor. We must always remember that the less important muscle must be sacrificed to the more important.

Lastly, cases of very extensive paralysis are totally unsuitable for this operation.

Time for Operation.—It should not be undertaken until it is quite certain that the paralysis is irremediable by the methods of treatment already described; and, especially if it is found that when the parts have been placed in appropriate positions, the muscles fail to respond in any way to electrical stimulation. In fact, it is only in the stationary stage of anterior poliomyelitis that this operation is employed. Some cases reach this stage soon, and some not till two years after the attack. We must, however, make certain that the muscles are not atrophied merely from disuse.

There has been a tendency in the past to regard tendon-transplantation as standing entirely by itself as a remedial operation; but, extended experience shows that in many cases, in the foot at least, it finds its best use as an adjunct to partial fixation procedures, such as arthrodesis.

Technique of the Operation.—As a preliminary measure, all secondary deformities, such as arcuatus or plantaris, are rectified by fasciotomy and wrenching. We have already described the intermediate and immediate or periosteal forms of transplantation. If we use the intermediate, it is generally conceded that the best results have been obtained by one of two procedures. Either joining a strip (see p. 627) of the re-inforcing tendon to one taken from the paralysed one, or, better still, laying the strips side by side and firmly uniting them. Undoubtedly, however, the most reliable results are reached by Lange's direct periosteal implantation. It is obvious that complete and perfect asepis is essential to success. Bradford and Soutter,[1] in addition to the ordinary preparation of the skin, thoroughly wash it with Harrington's solution, a combination of alcohol, hydrochloric acid, and corrosive sublimate.[2] Gloves and masks are used, and every detail is scrupulously attended to. The nature of the uniting material requires careful consideration. Some surgeons use catgut or prepared kangaroo tendons. The author, however, invariably employs mercurialised silk.[3] Lange has shown that the surest preventive of stitch-abscess is the thorough impregnation of the silk with mercury salt. Silk, of various thickness, is prepared; but, if it is boiled in water only, it often gives subsequent trouble and has to be taken out or suppurates out.

A skin incision of sufficient length and in the most convenient direction is made. We must be careful to have sufficient room for our operation, so as to avoid any twisting of the tendon at an angle, and we may also wish to see and ascertain by direct stimulation with sterilisable electrodes the condition of the muscles. Thus, a healthy muscle is dark red, and its tendon is glistening white; a paralysed muscle and tendon are yellow-white, a partially paralysed muscle is mottled, red and yellow, and the tendon is white. The last-named muscles will respond partly to stimuli, and cannot be regarded as entirely useless. In operating, the tendon sheaths

[1] *Amer. Jour. Orth. Surg.* vol. vi. No. 2, Nov. 1908, p. 192.

[2] Unfortunately these writers do not state the proportions, yet it ought to be quite easy to make such a solution. We suggest Pure Hydrochloric Acid ♏x., Corrosive sublimate gr. ii., Abs. alcohol Oj.

[3] The silk is prepared in the following way:—The skein of silk is undone and soaked for half an hour in ether, and then for a few minutes in alcohol. It is then boiled for one hour and placed for a week in a solution of 1 in 1000 biniodide of mercury. It is finally wound on to glass reels and always kept in this solution. Lange, *Amer. Journ. Orth. Surg.* vol. viii. 1910, No. 1, p. 17, now advocates paraffin-sublimate silk. The silk is first boiled in sublimate solution, and dried for two days under aseptic precautions. It is then boiled for one hour in paraffin (melting point, 60° C.).

should be interfered with as little as possible, and transplanted wherever feasible with the tendon itself, because the greater portion of the blood-supply is derived from the sheath.

Artificial Silk Tendons.—In the earlier operation of tendon-transplantation the re-inforced paralysed tendon often degenerated and became slack. Lange made experiments on the cadaver, and found that in a particular instance a tendon, periosteally attached, bore a weight of 14 to 15 kilos, whereas an inter-tendinous attachment did not carry more than 2 to 3 kilos.

We owe various advances to Lange. Finding, when he began tendon-transplantation, that silk sutures remained quietly embedded, he argued that if a short piece gave no trouble, why should not a longer piece of silk be used, and in his article in Joachimsthal's *Handbuch der orth. Chir.*, he states that he has practised his method of artificial elongation in over 200 cases with a great measure of success (Fig. 345). He lays stress upon the necessity of impregnating the silk with antiseptic material, and always employs drainage for the first 48 hours. Lange uses four strands to lengthen the tendon, and in attaching two or three muscles, six or eight strands are employed. Sometimes the strands used have been 20 or 25 centimetres in length.[1] The great merit of Lange's method is that he transfers the tendon, and attaches it to the bone at the spot most suitable for effective action. He found that the strands of mercurialised silk, left in the tissues as substitutes for tendons, are very durable. The artificial part of the tendon quickly increases in thickness, when the transplanted part begins to act. In one of his cases, six months after the operation, the artificial tendon was a quarter of an inch in diameter; in another case, twelve

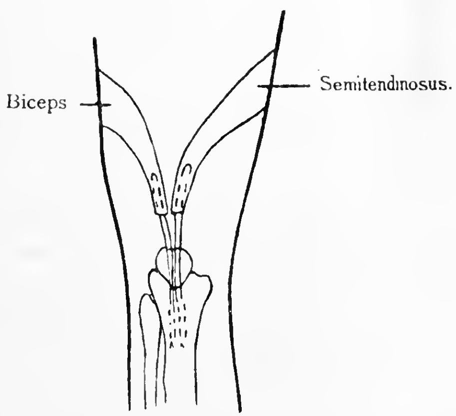


FIG. 345.—Elongation by Silk of the transferred Biceps and Semi-tendinosus, and attachment of the Silk Tendon to the tubercle of the tibia (Jackson Clarke).

[1] The silk he uses is Turner-Seide, Nos. 3 to 12, obtainable from Katsch, Schillerstrasse, Munich.

months after the operation, it was $\frac{3}{8}$ inch thick; and in a third case, two years afterwards, the tendon was "of the size of the little finger." The artificial prolongations appear as blue-white tough fibrous cords, in the centre of which the silk lies unaltered. Microscopical examination of an excised piece showed in the deeper, and therefore older layers of fibrous tissue near the silk, that

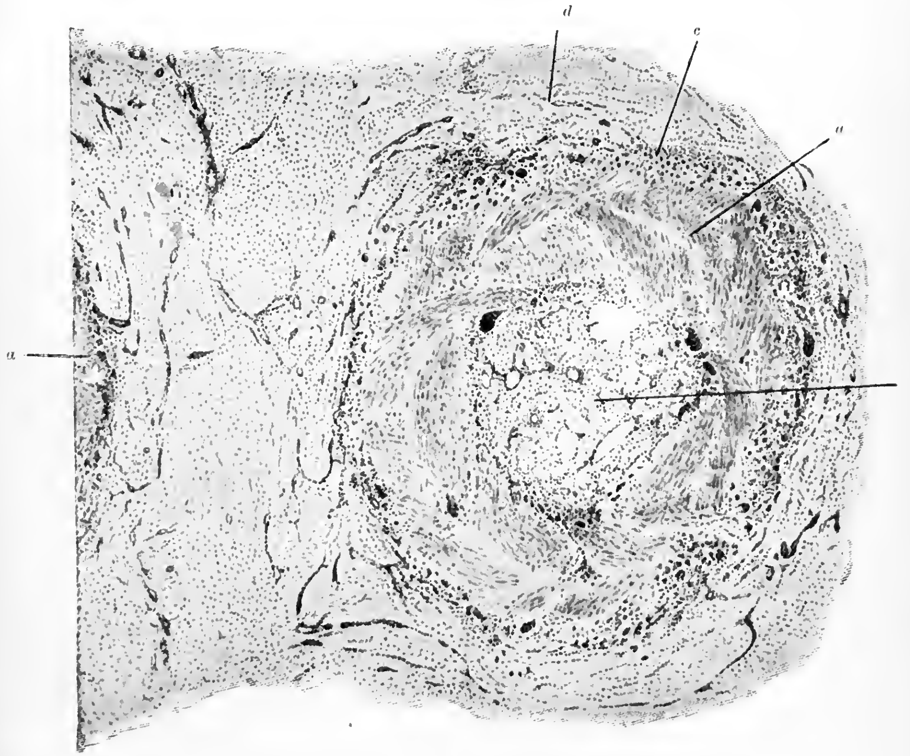


FIG. 346.—Transverse section through two artificial Tendons of Silk. (*a*) Silk strands; (*b*) young nucleated cells in the interior of a silk strand; (*c*) new fibrous material, similar to tendons, deposited around the silken cord; (*d*) cellular material of false sheath (Lange).

the structure was identical with that of a normal tendon. In the superficial layers the appearance was also tendinous, with the addition of scattered vessels and connective-tissue cells.

The author has used Lange's method [1] extensively in the foot, and at the knee-joint to prolong the tendons of the sartorius

[1] In the neighbourhood of the knee-joint, Lange has implanted a silk tendon 8 inches long.

and hamstrings to the tibia, also at the wrist to extend the tendons of the flexor carpi radialis and ulnaris, when they have been transplanted from the front to the back of the wrist. Of 63 cases, in only two has the silk come away, and this occurred when plain, non-mercurialised silk was used.

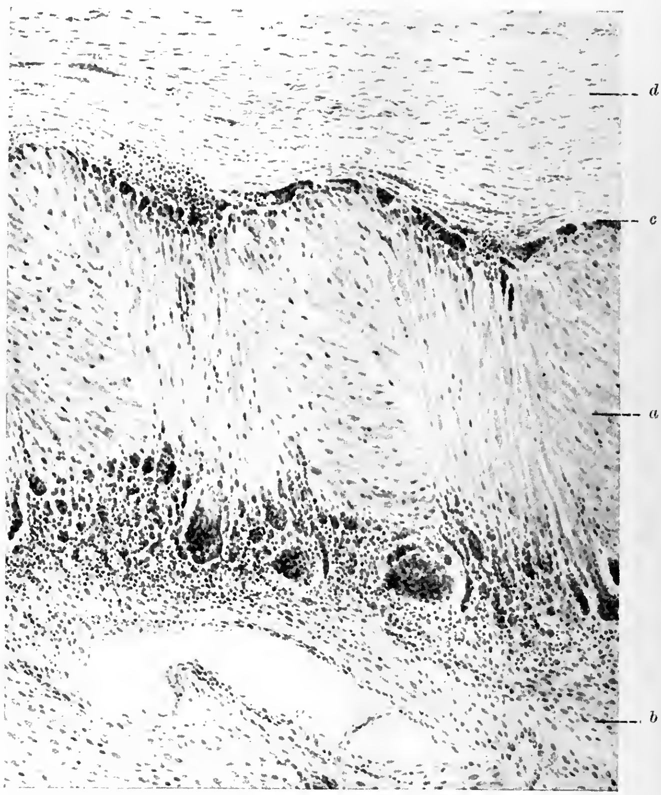


FIG. 347.—Transverse section through a well-developed Artificial Tendon of considerable diameter. For explanation of lettering, see Fig. 346 (Lange).

We will now go more fully into the details of the method of tendon transference as effected by Lange's method. The plan of campaign is made, and we decide whether or no we shall combine with our transplantation, shortening of paralysed tendons and relaxed ligaments, and exsection of soft tissues. As a rule, for tendon-transplantation two short incisions are preferable, unless we deem it wise to use a long one so as to ascertain the condition of the muscles. However, as primary union is desirable, shorter incisions are better, because healing is quicker. One of the incisions is made parallel to and at a short distance from the place where the re-inforcing tendon is exposed and divided, and the second is made over the site of its new insertion. As great a length as possible of the tendon or tendons is hooked out of the first wound, and into the lowest part silk of No. 1 or No. 2 is quilted. The silk is passed longitudinally into one side of the tendon, then across it and down the other side, so as to take firm hold, and the two ends should be of equal length.

FIG. 348.—Longitudinal section of an Artificial Silk Tendon (Lange). For explanation of lettering, see Fig. 346.

Bradford and Soutter[1] point out that the tendons and muscles should be protected as much as possible from unnecessary handling, and they must not to be allowed to become dry. Binnie has suggested that they be covered with sterilised vaseline when exposed.

The soft tissues are now tunnelled, and Bradford and Soutter have devised long-handled forceps, curved on the flat, for the purpose. The forceps holding the silk ends are passed through the

[1] Cf. Hunkin, "Muscle Transference, with Particular Reference to Operative Technic," *Amer. Jour. Orth. Surg.* vol. vi. No. 2, Nov. 1908, p. 202. Hunkin employs the Blackwall stitch. See figs. in his paper.

tissues, keeping as close to the bone as possible; and, through the second incision, which has been previously made, the silk ends are seized in other forceps. Tension is now made on the silk-ends. The degree of tension and the position of the part are all-important. It is placed in the over-corrected position, and the tendon is pulled upon, to the extreme limit of elasticity. If less than this, some "slack" must be taken up before it can act; if more than this, it is found that the muscle is over-stretched and does not act.

Either the tendon or its silken prolongation is fixed firmly to the periosteum or bone; and, we have frequently drilled a hole into the bone and drawn the silk strands through and fastened them. The best method of fixing the tendon is to turn up a flap of periosteum, drill a hole into the bone, draw the tendon through it, and suture the periosteum over the tendon end. Whenever silk is used, either for suturing the tendon in its new position or prolonging it, drainage for 48 hours is, as extended experience shows, essential to secure rapid healing. The wound is dressed, and a plaster of Paris bandage applied to the part in the corrected position, a window being left over the wound. In 48 hours the drain is removed, the part re-dressed, and it heals without interruption.

We must now speak of certain points in the operation and after-treatment, and we again emphasise the necessity of full correction or rather, over-correction of all secondary deformities before tendon-transplantation is undertaken. The tension of the re-inforcing muscle and tendon should, as nearly as possible, approach the normal, so that after attaching the latter, the position of the parts is exactly that corresponding to the movement which it is desired to attain. The re-inforcing tendon is then pulled upon to the limits of its elasticity and is firmly attached. The tendon sheaths are closed with fine cat-gut, and the deep fascia with buried sutures. During any subsequent manipulations no strain should be put upon the new attachment.

After-care of these Cases.—The parts are kept absolutely at rest in the new position for at least six weeks, in plaster of Paris. The greatest danger of relapse is when this is taken off, so that suitable supports should be employed both by night and day to limit the movements. And, here no fixed rules can be given; experience alone is useful. Movements must be limited at first, and then very gradually increased. The nutrition of the muscle of the transplanted tendon should be maintained at its highest point by very careful massage, and by weak electrical currents, and efforts are made to re-educate the transplanted muscle and tendon to their new functions. A great deal of the doubt as to the value of tendon-transplantation and tendon-suture has originated from the want of careful and sagacious after-treatment.

Therefore on the subject of after-treatment we quote *in extenso* the words of R. W. Lovett:[1] —

"Muscle-training is coming to occupy the prominent place in our therapeutics that it deserves, and is superior to either electricity and massage (although these are by no means to be neglected).[2] Muscle-training represents an attempt to secure a motor-impulse, which is transmitted through the motor cells controlling the special muscle, by means of which a contraction of the transferred muscle is secured. Frequent repetition of this process (1) educates the muscle to contract in its changed relations, (2) leads to improved nutrition from activity, (3) if repeated often enough, it leads to developmental hypertrophy of the exercised muscle.

"As a therapeutic measure it has the advantage of directness in being exactly what the muscle has got to do in restoring or improving function. But, if moderate developmental use is desirable, an excess of this by overloading the muscle is undesirable, and leads to relapse. Hence the need of protected and supported use in the early function, under weight-bearing. C. Fayette Taylor forty years ago pointed out this danger. 'To extend a muscle while in the act of contracting, that is, to overcome it, is at once to destroy its irritability and force.'

"To perform a tendon-transfer, to fix the leg in plaster for some weeks until muscular atrophy has become marked, and then to allow walking unprotected is bad treatment. Unless the operated-on leg is massaged from the sixth week, and the newly-transferred muscle is trained to its new function shortly afterwards, and unless this massage and training are carried over some weeks, the best results cannot be expected. No matter how good the operation, it must be followed up, or the operation will be regarded by the individual operator as an over-estimated procedure; if, on the other hand, he performs a sound and reasonable operation, and has his patient properly treated over a period of about six months, he will find it, in a large proportion of cases, one of the most satisfactory procedures in operative surgery."

Criticism of Tendon and Muscle-Transplantation.—It is necessary, in considering the results, to be clear how much of the improvement belongs to the correction of vicious attitudes, and how much to the return of function. The correction of vicious attitudes in infantile paralysis had been obtained in some measure before

[1] *Trans. XVI. Internat. Med. Cong.*, Sect. vii. 1st Fascic. p. 16.

[2] Words in brackets are the author's.

the more recent methods were introduced, and improvement had followed. All observers and even adverse critics are agreed that the return of active movement after tendon-transference has been partial and has resulted in an improved function of the limb. This expression of opinion is satisfactory, because any improvement, however slight, in the active function is to be welcomed. It is certain that the faradic excitation of the re-inforcing muscle is accompanied by tension in the paralysed tendon, that voluntary movement makes its appearance, and in time and with practice it increases in force and range. The indifferent results which have followed tendon-transplantation are due to certain obvious causes to which we shall now allude as causes of failure.

Causes of Failure.—These are :—

1. Insufficient preliminary correction of secondary deformity.

2. Improper selection of cases, the paralysis being often too extensive.

3. Attempting to use too weak or partially paralysed muscles, as re-inforcers.

4. Defective asepsis.

5. Insufficient freeing of the re-inforcing tendon, and inadequate tension of its muscle, at the time of its insertion.

6. Division of the nerve of the re-inforcing muscle in freeing the latter.

7. Defective attachment of the transferred muscle or tendon in its new position, and subsequent tearing away.

8. Bending the tendon round at an angle.

9. Throwing a strain too early upon transplanted tendons.

10. Expecting transplanted tendons to steady and control a flail-like joint.

11. Imperfect after-education.

12. In some cases, early adhesion of the tendon to surrounding parts, which is due to rough handling of the part or mutilation of the sheath. As much as possible of the sheath and adjacent fatty areolar tissue should be transferred with the tendon.

13. Too early removal of all apparatus, with the use of the limb in a faulty manner.

The means of avoiding these causes of failure will be obvious from what we have previously said.

Form of Paralysis to which Tendon Grafting is Applicable.—In estimating the value of this method, we must first consider it as an operation by itself, and not combined with other procedures. The best results have undoubtedly been obtained about the knee-joint. Goldthwait's operation of transplanting the sartorius, and Lange's modification of that operation by bringing the inner and outer hamstrings forward and attaching them to the tubercle of the tibia by artificially elongating their tendons, have proved eminently successful.[1]

The author's results have been most encouraging with this operation, and in over 40 per cent. of his cases, complete power of extension in the leg, both in standing and sitting, has followed, and partial power in 50 per cent. of the remainder. In the foot, the best results of tendon-grafting are obtained in limited paralysis where one muscle or a single group of muscles is affected. Thus, in paralysis of the tibialis anticus causing valgus, transference of one of the abductors of the foot to the inner side has restored the lost power, and in talipes varus transplantation of the tibialis anticus to the outer side has been followed by restoration of voluntary abduction. The more extensive the paralysis, the less likely is tendon-grafting, as the sole measure, to give good results; especially is this the case in the leg and foot, where stability is essential. Even when artificial silk ligaments are inserted, the prospects of satisfactory results vary inversely with the degree of weakness.

In the upper extremity the prognosis of simple transplantation of muscle or tendon is decidedly better. The author has had excellent results, so far as flexion of the forearm is concerned, in some cases of Erb-Duchenne paralysis, by transplanting a portion of the triceps into the biceps, an operation for which he is primarily responsible; and the results about the wrist and hand for drop-wrist, together with the replacement of lost extensor or flexor power in the fingers by using the carpal flexors as substitutes, are most encouraging.

How far, then, is Success obtained?—In estimating the success of these operations it is necessary to consider how far an apparently paralysed muscle is capable of recovery, if aided by removal of the harmful effects of constant stretching, and by re-inforcing or restoring its action. Even when muscles give the reaction of degeneration, we have no means, so far as I know, of measuring exactly what is the extent of degeneration, whether it is entirely distributed throughout the muscles, is in patches, or to what degree it has proceeded. On these points accurate and original observations are required.

[1] Cf. the author's cases Nos. 3, 4, 5, and 6, Hunterian Oration, *B.M.J.*, March 3, 1906, and Goldthwait, *Trans. Amer. Orth. Ass.* vol. x. p. 97. Six cases, 4 with decided improvement.

D. Koch [1] has shown that when the fatty degeneration of a paralysed muscle is scattered in small areas only, a large amount of regeneration of muscle fibres may take place in each area. If the entire muscle has been transformed into fat, no such regeneration can follow. The process of regeneration sets in some time after the paralysis and fatty degeneration, the latest time being seven to nine months. Every facility must, therefore, be given for the process of renewal by improving the function of the muscles.

There are two aspects from which the question of success may be considered. What improvement can be obtained under the strict personal care of a surgeon, experienced in these operations, who has complete control over his patient, and is aided by the intelligent co-operation of nurses and parents for a period, extending over many months or years? The other aspect is, What results can be expected under conditions that must necessarily confront both surgeon and patient in the course of treatment in a large hospital?

Dane and Townsend,[2] in 1904, collected 50 cases operated upon in hospital by various surgeons, and came to the conclusion that the best results so far as transference of tendon is concerned, were obtained by transplanting the tibialis anticus into the cuboid, the peronei into the inner side of the foot, and a strip of the tendo Achillis to the extensor aspect so as to relieve equinus. They, like the author, have no opinion of the permanent utility of Nicoladoni's operation of fixing the peronei to the tendo Achillis for talipes calcaneus. Indeed, as a pioneer operation, this was the most unfortunate example which could have been selected.

In planning the earlier operations, the fact was not sufficiently grasped that the foot is primarily a weight-bearing mechanism, that stability and fixation are the essentials, and that movements are secondary considerations. Nevertheless, as an adjunct to arthrodesis about the ankle and foot, it will be found that tendon-grafting is a most useful and justifiable procedure. The aim of arthrodesis is to give a firm ankle, the aim of tendon-grafting is to endow other parts of the foot with movements. Certain it is that tendon-transplantation is often followed by unexpected development of partially paralysed muscles. It is quite possible that the results in spastic paralysis will prove equal to, if not better than, in infantile paralysis. Gibney [3] has published the statistics of 74 cases, under the care of himself and

[1] *Münch. med. Wochenschr.*, July 1904.
[2] *Amer. Jour. of Orth. Surg.*, Aug. 1904.
[3] *Boston Med. and Surg. Jour.*, May 10, 1902.

his colleagues. Of 60 of these cases, Gibney regards 46 as good results and 14 as defective results; and by good results, we understand that he, as an experienced orthopædic surgeon, was satisfied.

So far as the knee, the arm and hand are concerned, the results are most satisfactory. Also for limited paralysis of the foot, tendon-transplantation is a successful operation; severe paralysis here, however, is treated by a combination of transplantation, arthrodesis, and artificial ligaments. One joint such as the ankle is fixed by arthrodesis, and other joints such as the medio-tarsal and calcaneo-astragaloid are aided by tendon-transplantation and artificial ligaments.

It is interesting to know the written opinions of experienced surgeons upon this subject. Mr. Jacobson, in *The Operations of Surgery*, 5th ed. vol. i. pp. 54-64, discusses the subject of tendon-transplantation, and gives copious extracts from the *Surgery of Paralyses.* He remarks: "I have given Messrs. Tubby and Jones' conclusions at length because of the pains they have taken to develop the different operations, and the authority with which they speak upon orthopædic subjects. But, it is right to state that there is another side to this question, and that opinions are far less favourable. . . . From America, where every fresh operation is at once tested largely and with much zest, we have warnings not to expect too much from tendon-transplantation in infantile paralysis."

Mr. Jacobson has, with his scrupulous accuracy and fairness, placed the matter before his readers, as he was cognisant of it at the time of writing in 1907. The more recent results were not then available, and the march of progress has been very rapid. The results of cases, which have been watched for several years, are now known. As he has alluded to the results in America, it is well to quote at length from articles which have appeared there since 1907.

E. H. Bradford and Robert Soutter,[1] writing in 1908 on "The Ultimate Results of the Surgical Treatment of Infantile Paralysis," remark: "It would not have been thought, from the numerous failures which followed the first attempts at tendon-transplantation, that an efficient method could have been devised which would be of use in a large percentage of cases. . . . The conclusions which are here presented are drawn from cases observed, many of them after observation for a number of years. . . . These cases number now 500, and have in all instances been carefully studied and the terminal results noted where possible." Attention is directed by these writers in their papers, "more particularly to paralytic

[1] *Amer. Jour. Orth. Surg.* vol. vi. No. 2, Nov. 1908, p. 184.

deformities of the lower extremity, and the results following the employment of silk strand elongation in tendon-transference, and the use of silk ligaments in the fixation of loose joints following infantile paralysis." They also allude to "Tubby's operation" of transplanting the pronator radii teres, and they remark that "it has been performed with success by several surgeons, and the writers would record four successful cases." Bradford and Soutter have reported their terminal results in the *Cleveland Medical Journal*,[1] June 1906, the *Boston Medical and Surgical Journal*, November 1907,[2] and the *American Journal of Orthopedic Surgery*, March 1908. They generalise from their results, and they conclude that "with suitable precautions, results of a satisfactory nature can be obtained in a large number of cases."

With this very modest opinion and well-weighed evidence before us, we turn to a more recent pronouncement, embodying the results of the labours of other members of the American Orthopedic Association. R. W. Lovett,[3] writing on paralytic deformities in 1909, points out that at the Boston Children's Hospital the early operations were not so successful as have been the later ones. "The operation was a new one, the Hospital was a pioneer in the matter, and the first cases naturally contained a larger number of unsatisfactory results than were seen later." The causes of failure, and the reasons for subsequent improvement are then given. Under improved conditions and with wider experience, "we now regard the operation in *suitably selected* cases as one strongly to be recommended to patients, and, in the great majority of such cases, as one followed by most satisfactory results."

Lovett sent a circular of inquiry to each member of the American Orthopedic Association, worded as follows:—

1. "Do you consider tendon-transplantation in properly selected cases as a useful and satisfactory operation?" The replies were:

Yes	34
Yes, qualified	2
Moderate	3
In some	1

The opinion is thus definitely expressed that it is a useful and satisfactory operation in suitably selected cases.

2. "Are your end-results satisfactory?" The replies were:

Yes	13
Yes, in suitably selected cases	7
Moderately	7
No	4
Sometimes	8

[1] Between 1895 and 1905, 62 cases were operated upon; the results in 48 of these were that in 33 improvement was noted.

[2] In 35 cases treated at the Boston Children's Hospital by periosteal transplantation, "all gave evidence of satisfactory improvement after the operation."

[3] *Trans. XVI. Int. Med. Cong.*, 1909, sect. vii. 1st fasc. p. 11.

Then follow other queries; but we pass on to

3. "Are your more recent operations more satisfactory than your earlier ones were?"

Yes	31
No	5
The same	1

We have quoted sufficient to show that the operation, as now practised, has a definite place in the surgical treatment of poliomyelitis, and that it is a recognised and approved procedure. Lange (*Amer. Jour. Orth. Surg.* vol. viii., 1910, No. 1, p. 20) says that "the transplantation of tendons has already brought endless blessing to our cripples, and it may with justice be counted amongst the greatest advances that orthopædic surgery has made in the last decade." We need not labour the point further, for this is the conclusion of the whole matter.

Arthrodesis

Arthrodesis [1] is artificial fixation of a joint in the most useful position, and finds its chief use in the treatment of infantile paralysis, when a joint is flail-like. The objects are to make the part stable, to lessen the weight of apparatus and subsequently to dispense with them; arthrodesis also provides a fixed point in the weak proximal segment of a limb, upon which important movements of the distal and non-paralysed segments may be based. The operation is practised most commonly at the ankle and in the joints of the foot, less often at the knee, and rarely at the shoulder. It is generally agreed that the hip, elbow, and wrist are joints not very suitable for arthrodesis.

Time for the Performance of the Operation

(1) When it is evident that no further recovery is to be expected in the affected muscles after conscientious trial of passive movement, mechanical support, massage, and electricity. Therefore

[1] Cf. *Report on Arthrodesis*, by Robert Jones. *Trans. XVI. Int. Med. Cong.*, 1909, 2nd fasc. p. 47. The report deals with: 1. The value of arthrodesis? 2. The best age for the operation? 3. What special precautions are taken to ensure bony union? 4. Which joints are the most favourable for the operation? 5. Is arthrodesis combined with tenotomy and tenoplasty? 6. Has deformity, due to irregular growth, resulted from arthrodesis? 7. If failure of the operation, its causes? 8. Suggested improvements in technique? Cf. also Lange's remarks, *Amer. Jour. Orth. Surg.* vol. viii., 1910, p. 13.

arthrodesis should not be performed earlier than two years after the onset of infantile paralysis.

(2) It is not an operation to be practised on young children; successful results, so far as satisfactory fixation of the joint is concerned, can only be obtained in patients aged ten years and upwards.

Indications

(1) As a means of fixation of flail-like ankle- and foot-joints, and occasionally of the knee and shoulder.

(2) When there is difficulty in obtaining and wearing apparatus to control loose joints.

(3) As a fixation-method, in combination with tendon-transplantation.

(4) Only after correction of the deformities due to gravity and contracture.

Arthrodesis in the Lower Extremity

The operation is a simple one. It consists essentially of denuding the joint completely of all its cartilage, and retaining the parts in position, until firm ankylosis has ensued. The operation should always be commenced by a free incision, which enables the surgeon to see accurately what he is doing.

Arthrodesis at the Ankle.—An Esmarch's bandage is applied, and an incision, much in favour with the author, is a curved one commencing at the anterior border of the fibula about two inches above the ankle-joint, passing down to the tip of the external malleolus and then curving forwards nearly to the base of the fifth metatarsal bone. The incision is carried down to the bone and serves not only for the ankle but also for the calcaneo-cuboid, and, if necessary, for the calcaneo-astragaloid joint. The tissues are rapidly and freely turned back by a periosteal elevator, working inwards at first, then downward and outward, so as to expose the lower end of the tibia and fibula, the astragalus, and part of the os calcis. The ankle-joint is then opened and the foot wrenched forcibly inward, so that the articular portion of the astragalus is well exposed. All its cartilage, especially that on the lateral articular aspects, is then removed. Then, forcing the foot directly downwards, the articular surfaces of the tibia and fibula are well exposed, and from them every portion of articular cartilage and synovial membrane is removed. As an additional precaution, the author freely stipples the joint surfaces, and in some cases grooves them. The Esmarch's bandage is then removed, hæmorrhage is arrested, the divided ligaments are carefully sewn together with silk, and, in very flail-like joints, artificial silk ligaments are inserted. The wound is closed and dressed, and the foot put

FIG. 349.

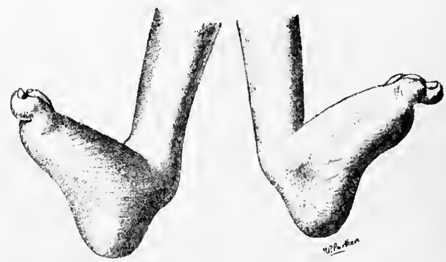


FIG. 350.

FIG. 351.

Three views of an ankle, flail-like as a result of Infantile Paralysis, and suitable for Arthrodesis.

up in plaster of Paris at a right angle and somewhat inverted, because experience shows that, if this precaution is not taken, when weight is borne upon the part, it becomes everted and the arch falls.

There are some points of importance to be borne in mind when carrying out this operation in cases of talipes equinus. Instead of the antero-external incision, an anterior incision is used, dividing the tendons, the anterior tibial artery, vein and nerve. Before the tendons are severed, a suture is passed through each one above and below the point of division, as it is found that the proximal portions of the tendons sometimes retreat upward into their sheaths and are difficult to find. After the joint has been erased, a portion should be excised from each tendon so as to shorten it, the ends joined together, and artificial anterior and lateral ligaments are put in. There is no necessity to trouble about suturing the nerve, as sensation invariably returns in two or three weeks. Some operators open the joint by a perpendicular incision along the mid-line in front, especially when the astragalus

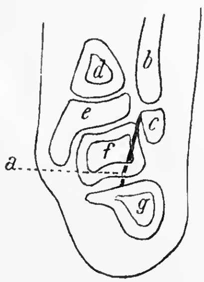


FIG. 352.

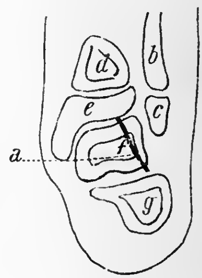


FIG. 353.

FIG. 352.—Vertical section through the bones about the Ankle in a child, to illustrate a method of correcting a Varoid position of the foot, when performing Arthrodesis of the ankle: *a*, oblique line of section of astragalus *f*; *b*, *c*, fibula; *d*, shaft, and *e*, lower epiphysis of tibia; *g*, os calcis (Tubby and Jones, *Surgery of Paralyses*).

FIG. 353.—Vertical section through the bones about the Ankle in a child. The oblique section *a* is made in the opposite direction through the astragalus *f*, so as to correct valgus deformity at the ankle (Tubby and Jones, *Surgery of Paralyses*).

is displaced forwards. Finally, it is expedient in talipes calcaneus to make a posterior incision over the tendo Achillis, draw it to one side, and then attack the articular cartilages. The objection to this incision is that it is much more difficult to get a good view of the joint and to be sure that complete removal of cartilage has been effected. For most purposes the antero-external incision is the best, as it gives a good view of the joint, except perhaps on the inner side of the astragalus and the corresponding surface of the internal malleolus. This difficulty can be overcome, however, by free division of the deltoid ligament with a strong knife.

It is found by experience that, after arthrodesis of the ankle, the foot has a tendency to become everted and flat. In order to overcome this difficulty, a wedge-shaped section of bone may be taken from the outer surface of the astragalus with the base upward (Fig. 353). If, however, the operation has been performed for varus, the base of the wedge of bone taken from the astragalus should be placed downward (Fig. 352). In no instance should more cartilage be removed from the lower end of the tibia than is necessary to secure bony union, and care must be taken, in gouging, not to interfere with the epiphysial line, otherwise there will be considerable shortening ultimately. The removal of a thin wedge from the astragalus produces very little effect on the length of the limb. Before sewing up the wound, the foot is held in an over-corrected position and the redundant portion of skin and subcutaneous tissue removed, in talipes varus from the outer, and in talipes valgus from the inner side; and stitches are inserted to draw the edges of the gap together. It is often advisable, also, to exsect portions of relaxed tendons. Thus, for talipes varus portions of the peronei, and, for valgus portions of the adductor tendons, may be exsected, the ends being re-united.

In many cases it is found that when a sufficiency of cartilage has been removed to give a raw surface, the astragalus fits loosely into the mortice of the tibia and fibula. It is essential for the success of the operation that firm ankylosis be secured; and this is much more likely to follow if the joint-surfaces are pressed as closely together as possible. Lateral strain also is more surely neutralised. A proceeding, initiated by Goldthwait,[1] is an attempt to secure a closer fitting of the parts. He performs an oblique osteotomy of the lowest part of the shaft of the fibula from above downwards and from without inwards, so that the lower end of the section on the inner side extends into the ankle-joint. The lower end of the fibula is then bent inwards and pressed against the external articular surface of the astragalus (see Figs. 354, 355, 356). In applying the dressing, care is taken to see that the position of the bones is not altered. The part is then fixed in a plaster of Paris bandage and not disturbed for two weeks. At the end of that time the skin-sutures are removed, a careful examination is made to see that the parts are in their correct position, and the plaster re-applied. It should be worn in most cases for three months, and in others for as long as six months. I venture to suggest that closer cramping of the mortice of the tibia and fibula may be secured in Goldthwait's procedure, if a vertical slice were taken off the outer side of the tibia and the inner

[1] *Amer. Jour. Orth. Surg.*, Jan. 1908, p. 271.

side of the fibula, after the oblique osteotomy of the fibula has been done.

The object of the operation is to secure bony ankylosis at the ankle.[1] Many failures in this respect have been recorded, and foreign substances have been inserted. The author has found that a good plan to secure firm ankylosis is to insert a screw about 3-3½ inches long from the under surface of the os calcis through the astragalus into the tibia, and leave it there for three or four months, the part being enclosed in a plaster bandage. By

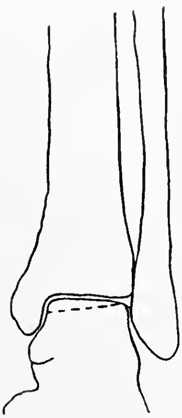


FIG. 354.—To illustrate Goldthwait's procedure in Arthrodesis of the Ankle to secure Ankylosis. The dotted line indicates the line of section of the upper articular surface of the astragalus.

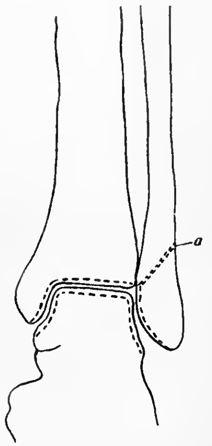


FIG. 355.—Goldthwait's procedure in Arthrodesis. The dotted lines indicate the area of removal of the articular cartilages, and the oblique osteotomy of the fibula.

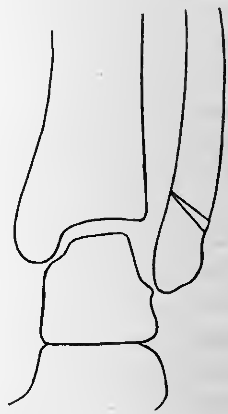


FIG. 356. — Goldthwait's procedure. The lower end of the fibula is "cramped" against the external surface of the astragalus.

abstaining from operating under the age of eight years, by careful though free removal of the articular cartilages and synovial membrane, by gouging the bony surfaces, by shortening lengthened tendons, and exsecting portions of soft tissues on the relaxed side of the joint, and by keeping the part immobile for a prolonged period, firm ankylosis follows.

Arthrodesis of the Calcaneo-Astragaloid and other Joints of the Foot.—This procedure is particularly indicated when varus or valgus is present, and it is often combined with the operation at

[1] Cf. *Report on Arthrodesis*, Robert Jones, *XVI. Internat. Med. Congress*, sect. vii. p. 47.

the ankle. The calcaneo-astragaloid joint should be freely opened from the outer side, the ligaments divided and the cartilages removed, so that two flat surfaces are exposed. The ligaments are then sutured.

In talipes equinus, arthrodesis of the medio-tarsal joint is necessary and can be performed from the external incision at the same time that the ankle is operated on. If the foot is adducted, a wedge may be taken from the outer part of the mediotarsal joint, and if abducted from the inner part of the joint.

Arthrodesis of the Foot in combination with Tendon-Transplantation.—When a joint is weak and deformed, an arthrodesis is performed to stiffen it, and tendon-transplantation is carried out elsewhere. Thus, in paralytic valgus the astragalo-scaphoid joint is fixed, and the tibialis anticus tendon is re-inforced by the peroneus brevis, and is re-inserted farther forward. If varus is present, the calcaneo-cuboid joint is arthrodesed, and the peroneus brevis is lengthened and transferred forwards on the foot. It may also be necessary to exsect a wedge from the calcaneo-cuboid joint. In dealing with equinus or calcaneus, the ankle and the calcaneo-astragaloid joints may require stiffening. The combination of arthrodesis and tendon-transplantation gives infinitely better results, so far as stability is concerned, than tendon-transplantation alone; and, as new movements are added to the foot, it becomes more generally useful than when arthrodesis alone is performed. Whenever possible, the combined operations ought to be carried out. This is particularly the case in treating severe talipes calcaneus.

There need be no anxiety as to the healing of paralysed parts, for they unite quickly and seem to be more capable of withstanding extensive disturbance than normal tissues. In adults, the arthrodesed joint often remains painful for two months or longer, after weight is borne upon it, but eventually it loses its sensitiveness.

Arthrodesis at the Knee is performed for flail-like conditions of the joint and occasionally for flexion with lateral deformity. It is not to be recommended to those patients who have ample means to obtain and renew mechanical supports; and, they feel acutely the disadvantage of not being able to bend the knee when sitting. However, to a working lad it may be a great boon to be independent of supports with their expense and worry. These cases should be treated in accordance with the patient's wishes, bearing in mind that he may know quite well what will suit him best. A distinct drawback to arthrodesis at the knee is that a stiff limb of such a length, especially if the bones are fragile, is liable to fracture.

The operation is fully justified when we have to deal with an ill-nourished limb and a flexed knee with external rotation and partial dislocation backward of the tibia. The arthrodesis then partakes of the nature of a wedge-shaped exsection.

The Operation.—A tourniquet is applied and an incision is made across the front of the joint, traversing half its circumference, and it is curved so as to pass below the patella. The flap is turned up and the divided vessels ligatured; the semilunar cartilages are next removed, and with a sharp, short-bladed knife or gouge, the cartilage is peeled off the underlying bones, so as to leave raw surfaces over the whole of their extent. The crucial ligaments may or may not be removed. It is also advisable to freshen the posterior surface of the patella, and to fashion flat surfaces on the anterior aspects of the tibia and femur to which the freshened patellar surface may adhere.[1] All hæmorrhage having been arrested, the structures are carefully re-united by deep and superficial sutures. A back and two side splints are preferable until the stitches are removed; then the limb is placed in a plaster bandage from the pelvis to the ankle for the first month; and after that the spica may be removed from the pelvis. For the succeeding six to twelve months a support from the groin to the ankle is to be worn, so as to ensure complete consolidation of the parts.

Arthrodesis in the Upper Extremity

The *elbow-joint* is not, as a rule, suitable for this operation, because it frequently happens that some of its muscles escape paralysis, and therefore it can be rendered useful. The same remarks apply to the *wrist*. Moreover, we can render these joints more stable by excision of skin and subcutaneous tissue (Vol. II. p. 625).

At the *shoulder* artificial fixation is practised from time to time. The operation here is very useful, when some or all the muscles acting on the elbow are intact, and enables the hand to be used about the neck and mouth. Arthrodesis is therefore

[1] The same idea was subsequently brought forward by Russell and Hibbs: "An Operation for Stiffening the Knee-joint," *Ann. Surg.* vol. liii. No. 3, March 1911, pp. 404-411.

recommended when the paralysis about the shoulder is such that it is desirable to secure a fixed point for the movements of the joints below; especially is this the case, if the movements of the scapula are retained and power in the muscles of the upper arm is lost, with no prospect of restoring them either by tendon-transplantation or nerve-anastomosis. Arthrodesis is also applicable when these measures have been tried and have failed. If the surgeon should decide that the use of the limb will be improved by making a firm base at the shoulder from which muscles may act, arthrodesis is indicated. When the paralysis affects all the vertebro-scapular and scapulo-humeral muscles, operative interference is useless. The operation, however, is of use when dislocation of the shoulder-joint exists, due to paralysis of the scapulo-humeral muscles.

Arthrodesis at the Shoulder-Joint.—An incision, in the length of the limb, is commenced a little inside the acromio-clavicular articulation and carried downwards in the interval between the pectoralis major and the deltoid. The capsule is incised in the bicipital groove and the coraco-acromial ligament divided, the biceps tendon being preserved. The synovial membrane and cartilages are removed, and the head of the humerus is brought out of the wound, any obstructing muscles and tendons being reflected. In order to reach the glenoid cavity it may be necessary to divide the capsule transversely. The head of the humerus is then shaped so that its antero-internal quadrant fits the flattened site of the glenoid cavity, and the bone is fixed in abduction of 45° and in internal rotation (Vulpius). Silver sutures are then inserted, one or two between the head of the humerus and the scapula, and the other between the head of the humerus and the acromion. Resection of a portion of the elongated capsule, so as to shorten it, may be practised, in order to assist in the immobilisation of the joint. The limb should, in both cases, be fixed for twelve weeks.

Fixation of the Elbow-Joint at a Permanent Right Angle.—A large number of cases of infantile paralysis occur where all the muscles, governing the elbow, are paralysed, whilst those of the hand have escaped. The limb is almost useless to the patient, as the shoulder muscles often participate in the affection. It hangs loosely at the patient's side and is of no use for feeding purposes, for it can only be lifted by the opposite hand. To obtain fixation of the elbow at a right angle is a great advantage, particularly in combination with arthrodesis of the shoulder-joint. Robert Jones has originated and carried out a simple method of fixing the elbow at a right angle[1] (Figs. 357-361).

FIG. 357.

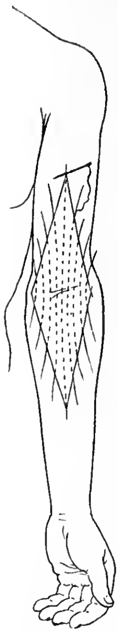


FIG. 358.

FIG. 359.

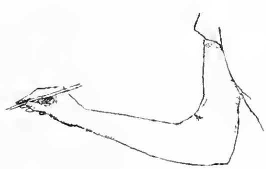


FIG. 360.

FIG. 361.

FIGS. 357 to 361.—To illustrate R. Jones' operation for fixing a Flail-like Elbow-Joint at a Right Angle.

FIG. 357.—A diamond-shape portion of Skin and Subcutaneous Tissue is being removed.
FIG. 358.—Method of passing the Sutures.
FIG. 359.—The Sutures tied.
FIGS. 360, 361.—The Results of the operation.

An extensive diamond-shaped incision, with its long axis in the

[1] Tubby and Jones, *Surgery of Paralyses*, p. 63.

length of the limb, is made, involving the entire surface of the upper third of the forearm and lower third of the arm; the skin within this area is dissected off, and the upper edges of the incision are stitched to the lower. Mr. Jones reports that he has had considerable success with this method in five cases, and even if the scar does yield, a further exsection can be done. He says, "the contraction of the elbow after burns[1] confirms the correctness of the practice, for it is in the experience of most surgeons that severe contractions sometimes occur at the bend of the elbow even when small areas of skin are involved." No splint is necessary after the operation, a sling for the hand being quite sufficient, this being used for some months until contraction is well advanced.

Arthrodesis at the Wrist.—This operation is seldom practised, because an ankylosed wrist is more of a hindrance than a help. The method of hyper-extension by means of splints should be most patiently tried before any operative procedure is attempted. If, on passively extending the wrist, it is found that there is even a flicker of movement in the extensor muscles, success may be predicted by the use of the hyper-extension method, massage, and electricity. When it appears that the extensor muscles are hopelessly paralysed, transplantation of the flexor carpi radialis and ulnaris, with exsection of skin on the extensor surface of the joint, is recommended.

Osteotomy

In the treatment of paralytic deformities, linear or wedge-shaped osteotomy is performed. It is usually done at the knee for paralytic genu valgum, and, as a rule, a linear incision is sufficient. Wedge-shaped osteotomy about the knee-joint is reserved for those cases where there is valgus or varus deformity with contraction and contracture of the ham-strings, rotation inward and displacement backwards of the tibia, and dislocation of the lower end of the femur.

Osteotomy, both linear and wedge-shaped, is required also in the treatment of inveterate cases of talipes varus or valgus, and may be combined with tendon-transference, tendon-shortening, the insertion of artificial ligaments, and arthrodesis.

[1] I would, however, point out that whilst the habit or tendency of scars from burns is to contract, the history of scars from clean incisions, made under aseptic precautions, is quite the contrary. As examples I suggest, the scar after open division of the sterno-mastoid, and that made in the abdominal wall for relapsing appendicitis.

Nerve-Transference, Nerve-Anastomosis, and Nerve-Grafting

Since 1882 a large amount of work has been done on muscle-transplantation and tendon-transference, and the operation is now approved. It therefore seemed not unreasonable that the step should be taken from muscles and tendons to nerves. If we can succeed in conveying impulses to muscles from a healthy part of the cord by a nerve channel, other than the paralysed one, the muscle substance which has not undergone complete degeneration will contract. In fact the principle has now been established that the central end of an efferent fibre can make functional connection with the peripheral end of any other efferent fibre of the same class, whatever be the normal actions produced by the two nerve fibres.[1] Or, to put it succinctly, the brain requires movements and takes little note of nerves except as channels for the passage of impulses, and regards muscles only as means of mobility. The nature of the movement depends upon the origin and insertion of the muscles. If we alter them, a new movement is gradually acquired. Spitzy [2] is responsible for the statement that muscles which have been atrophied (not degenerated, however) for eight years may become active if a new path of nerve-connection is established. The extraordinary results obtained from nerve-crossing have opened up a very fascinating field of surgery.

It appears that the earliest experiment in this direction was performed by Fleurens.[3] He divided the nerves of the brachial plexus in a cock, one set of nerves supplying the muscles on the superior and the other on the inferior surface of the wing. He then joined the proximal end of one set to the distal end of the other, and *vice versa*. Co-ordinated movement was observed in the limb after a time.

In crossing experiments, there is considerable risk of the nerves at the points of junction becoming matted into a common cicatrix, and one of the essentials in nerve-anastomosis is to guard against this. The best method is to use cargile membrane.[4] Langley united the proximal end of the vagus to the distal end of the cervical sympathetic,[5] and found that

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[1] Langley and Anderson, *Jour. of Phys.*, 1904, vol. xxxi. No. 5.

[2] *Annals of Surgery*, vol. xxxviii., and *Report of Proceedings German Surg. Cong.*, 1903.

[3] *Récherches expérimentales sur les propriétés et les functions du système nerveux*, 1824.

[4] Cargile membrane is the thin membranous peritoneum of the ox, suitably prepared, sterilised, and hardened by chromic acid, so that it resists absorption for ten, twenty, or thirty days, according to the degree of hardening.

[5] *Proc. Roy. Soc.* vol. lxii.

the vagus had acquired an influence over the centres innervated by the latter nerve.

Stefani,[1] Cunningham,[2] and Kennedy[3] performed crossing experiments on the nerves of the limbs, with recovery of function. In fact Kennedy interchanged the nerve-supply of the whole of the flexors with that of the extensors, so that stimulation of the musculo-spiral nerve above the line of suture resulted in flexion and *vice versa.* He further found that there had been an interchange of the cortical centres. For much of the information on these matters we are indebted to articles and investigation on the regeneration of nerves by Kilvington.[4]

The conclusion of Kennedy that the cortical areas of flexion and extension are interchanged after crossing, and stimulation results in the production of co-ordinated muscular action, is a most useful one and goes far to justify surgical interference with the nerve-supply to muscles.

In addition to complete crossing, there are other forms of nerve-anastomosis. Thus, the central end of one nerve may be joined to the peripheral ends of two or more nerves, as, for instance, in facio-accessory anastomosis the central end of the spinal accessory is split, and one part is sutured to its own peripheral end, the other to the peripheral end of the facial. Kennedy reported a successful case of this operation, and Kilvington anastomosed the facial nerve to the hypoglossal in a dog, with good results.

Other forms[5] of operations on nerves are :—

1. Lateral implantation of the peripheral segment of the paralysed into the sound nerve.
2. End-to-end junction of the peripheral segment of the affected nerve with the central end of a slip from the sound nerve.
3. A slip from the sound nerve is inserted into the paralysed nerve.
4. End-to-end junction of both central and peripheral ends of the affected nerve into the split segment of the paralysed nerve (Figs. 362-365).

As to the question of regeneration of nerves after section, there are two views. The older, or the Wallerian one, is that no regeneration takes place at all in the peripheral end, unless it is connected with its own central end or that of some other nerve. The new view is championed strongly by Ballance and Purves Stewart,[6] who conclude from their work that a considerable amount of regeneration takes place in the distal end of

[1] *Archiv der Anat. u. Phys.*, 1856.

[2] *Am. Jour. Phys.* vol. i., 1898.

[3] "Restoration of Co-ordinated Movements after Nerve-Crossing and Interchange of Function of Cerebral Cortical Centres."

[4] *Brit. Med. Jour.*, Apr. 29, 1904, p. 935; Sept. 16, 1905, p. 625; 1907, vol. i. p. 988; and 1908, vol. i. p. 1414. Also *Intercol. Med. Jour. Aust.*, Nov. 20, 1909.

[5] See illustrations, *Med. Annual*, p. 410, 1907.

[6] *Healing of Nerves*, 1901.

a cut nerve, when it is severed from its central end. Langley and Anderson's[1] experiments, however, cast very considerable doubt upon the new view.

Kilvington's[2] experiments upon the internal and external poplitcal nerves of dogs show that the central end of one nerve may innervate muscles through the peripheral ends of two nerves, supplying antagonists; that is to say, that there has been a re-education in co-ordination. In these experiments of Kilvington's, however, especially when the central end of one nerve is joined to the distal ends of two nerves, we are face to face with a distinct difficulty. It is shown that the number of nerve-fibres in the two distal trunks conjoined is greater than in the central

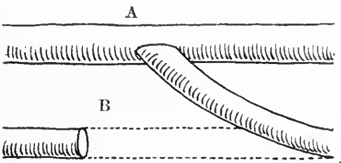

FIG. 362.

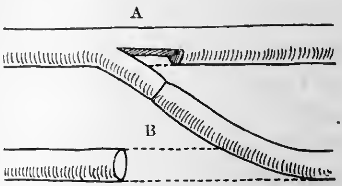

FIG. 363.

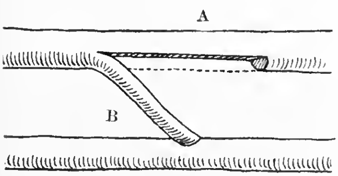

FIG. 364.

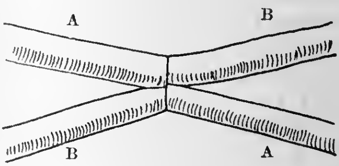

FIG. 365.

Diagrammatic representations of various methods of Nerve-Anastomosis. A, represents the unaffected, and B, the affected nerve. Fig. 362, Lateral anastomosis; Fig. 363, End-to-end anastomosis of the peripheral segment of a paralysed nerve, with the central end of a slip from a re-inforcing nerve; Fig. 364, the paralysed nerve re-inforced by a slip from the healthy nerve; Fig. 365, End-to-end anastomosis of both central and peripheral ends of the affected nerve with the divided ends of the sound nerve (after Spiller, Frazier, and van Kaathoven).

nerve-trunk. It therefore follows that if function is re-established, the nerve-fibres in the central end must divide into two or more branches. Now, if the branches of the central axis cylinders pass down one and the same distal trunk, restoration of co-ordinate movements should not be interfered with; but if they go down opposing peripheral nerves, then antagonism must follow; and in this way some of the unsuccessful results obtained in man may be explained.

Spitzy[3] operated on dogs, grafting the nervus peroneus to the nervus tibialis, inserting the former into a longitudinal slit in the latter. In the course of four months the function of the limb was perfectly normal, and it was proved by electrical stimulation that conduction was re-established

[1] *Jour. of Phys.* vol. xxxi. No. 5. [2] *Loc. sup. cit.*
[3] *Zeitschr. f. orth. Chir.* vol. xiv. No. 1.

in the peroneal territory through the nervus tibialis. The same surgeon [1] also attempted to innervate the paralysed anterior crural from the obturator nerve, using the superficial branch of the latter, and he found that in dogs, three months after the operation, the power of extension of the leg had returned. It is, however, somewhat surprising that so small a nerve as the superficial branch of the obturator should be able to innervate so large a trunk as the anterior crural. Spitzy in his paper gives very full references to, and a complete bibliography of, nerve-grafting. We believe we are right in saying that the operation on man has failed, for the reason that the small obturator branch cannot re-vivify so large a trunk as the anterior crural.

Application of Neuroplasty to Surgery

Facial Paralysis.—Although this affection does not strictly come under the description of anterior poliomyelitis, yet it is convenient to refer to these pioneer cases here.

Faure and Furet [2] in 1898 joined the trapezial portion of the spinal accessory to the divided facial without success. Robert Kennedy [3] performed later the first successful Faure-Furet operation of facio-accessory anastomosis in man. Cushing,[4] in a traumatic case of facial paralysis, transferred the proximal stem of the divided nervus accessorius *in toto* into the distal facial, and in six months the patient was described as being normal. Hackenbruch [5] reported a successful case of facio-accessory anastomosis in a girl aged eight years, who had suffered from facial paralysis for seven and three-quarter years. This case is interesting as showing that muscles deprived for nearly eight years of their nerve-supply can be regenerated by re-transmitting impulses from the brain to them, and it is of importance, therefore, in assessing the value of nerve-anastomosis in dealing with old-standing cases of infantile paralysis.

At the same Congress, Korte [6] showed a patient in whom, one and a half years previously, he inserted the peripheral stump of the facial into the hypoglossal with much benefit.

[1] *Wiener klin. Wochenschr.*, 1905, No. 3.

[2] *Gaz. des hôp.*, 1898, mars 8, p. 259. Also *Travaux de chirurgie neurologique*, 1902, p. 92; *Rev. de chir. trans.* xviii. p. 1098, 1898. Improvement in this case was noted at a later date, and in 1901 (Congrès de Chir. Paris, 1901) Faure describes it as a partial success.

[3] *Trans. Physiol. Soc.*, 1901.

[4] *Jour. Nervous and Mental Disorders*, 1903, p. 367.

[5] *Ann. of Surgery*, vol. xxxviii., and *Report of Proceedings German Surgical Congress*, 1903.

[6] *Verhandlungsschrift d. Kongress f. Chir.*, 1903.

Ballance and Purves Stewart [1] have performed seven facio-accessory and some facio-hypoglossal anastomoses. They prefer the latter procedure to the former, because associated movements of the shoulder and face are not evoked, and they recommend that the operation should be carried out, if the case shows no signs of spontaneous recovery after six months. In justice to them, we must add that their cases of facio-hypoglossal anastomosis were done before Korte's in Germany.

The author has grafted the distal end of the facial into the hypoglossal with marked success. The notes of the case are detailed in the Hunterian Oration, 1906,[2] and the patient was shown at the Clinical Society of London.[3] Six months after the operation the muscles supplied by the facial nerve had regained their power almost entirely, although when both sides of the face were drawn into action the weak side was overpowered somewhat by the stronger side. He was shown also to the Royal Society of Medicine in March 1909.[4] It was then difficult to distinguish which side of the face had been affected; except that there was a slight droop at the left angle of the mouth, all movements and functions of the affected side were perfect. There was entire absence of associated movements of the tongue and face; the tongue could be protruded directly without deviation, and its left half was not wasted.

Nerve-Anastomosis Operations on the Upper Extremity.—In cases of Erb-Duchenne paralysis or of infantile paralysis affecting part of the brachial plexus, it seems that nerve-anastomosis presents great possibilities. Wilfred Harris and Warren Low [5] have described three cases in which they operated on the fifth cervical root in the neck. Two were cases of Erb's paralysis in adults, and one was an example of infantile paralysis of the shoulder. A letter from the author, addressed to Dr. Wilfred Harris, elicited from him the following reply, dated November 2, 1906:—

Neither of the cases, with the Erb's paralysis, recovered any power in the deltoid or biceps, although one recovered sensation in the hand over the area supplied by the sixth cervical segment. The third case, that of a child with infantile paralysis, recovered very fairly, so that she can put the arm straight up over the head, recovery of power being first noticed six months after the operation.[6]

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[1] *B.M.J.*, May 2, 1903; and *Westminster Hospital Reports*, 1905, vol. xiv. p. 40.

[2] *B.M.J.*, March 3, 1906.

[3] *Clin. Soc. Trans.* vol. xl. p. 264.

[4] *Proceedings Roy. Soc. Med.* for March 1909.

[5] *B.M.J.*, 1903, vol. ii. p. 976.

[6] See also *Clin. Soc. Trans.*, 1904.

The author has grafted a slip from the outer part of the fifth nerve-root into the sixth for paralysis of the deltoid in a boy aged ten, who had been paralysed from birth. Partial recovery of power and some re-development of the muscle followed in fourteen months. In this case the exact position of the fibres supplying the deltoid was verified by using sterilised electrodes at the operation. We shall also allude to a partially successful case, in the author's practice, of operation upon the brachial plexus for paralysis following traumatism. For the present, however, we must leave the question of brachial birth palsy and traumatic paralysis.

In infantile paralysis of the serratus magnus, it would be well to entertain the possibility of separating the fibres of the posterior thoracic nerve from the fifth and sixth nerves, and re-inserting them into the seventh.[1] Paralysis of this muscle has been successfully treated by muscle-grafting by the author.[2]

For paralysis of the musculo-spiral nerve, Sick and Sanger[3] transferred the distal stump of the paralysed nerve into the neighbouring intact median, and obtained a good result.

Nerve - Anastomosis of the Lower Extremity.—Spitzy's[4] experiments on dogs have already been alluded to. He advocates what is called central implantation, especially in the case of large nerve-trunks. This consists of making a slip from an intact nerve, and fixing the free end into a longitudinal slit in the paralysed nerve.

Encouraged by the work of Henriksen,[5] Young,[6] Spiller,[7] Foramitti[8] and Müntz,[9] Spitzy neurotised the paralysed anterior crural by transplanting into it the superficial branch of the obturator. Spitzy in his communications gives the steps of the procedure, and in the cases of children on which he operated the results are said to be encouraging, but we await a further report.

Operations on the Peripheral Nerves.—In infantile paralysis

[1] In dealing with paralysis of the serratus magnus muscle Sherren's (*Injuries of Nerves and their Treatment*, London, 1908) remarks are of great interest.

[2] *B.M.J.*, October 19, 1904.

[3] *Gaz. des hôp.*, March 8, 1898.

[4] *Wiener klin. Wochenschr.*, 1905, No. 3 ; and *Zeitschr. f. orth. Chir.* vol. xiv. No. 1.

[5] "Nervensutur und Nervenregeneration," *Zeitschr. nach Centralblatt f. Chir.*, 1904.

[6] *Trans. Amer. Orth. Assoc.*, 1904.

[7] "Surgical Treatment of Facial Palsy," *University of Pennsylvania Med. Bull.*, November 1903.

[8] "Zur Technik der Nervennaht," Langenbeck's *Arch.* Bd. lxxiii. p. 3.

[9] "Durch Nervenanastomose geheilte Facialislähmung," *Centralbl. f. Chir.*, 1904, xxii.

of the lower extremity the majority of cases fall into two groups: talipes equino-varus, where the external popliteal nerve is at fault, and calcaneo-valgus, where the internal popliteal nerve fibres are atrophied. The close relationship of these two large nerves in the popliteal space, and their comparatively superficial situation, naturally render them very suitable material for a nerve-grafting operation.

Various forms of anastomosis have been carried out. The healthy nerve may be partly cut across, and the peripheral end of the paralysed one, with the epineurium turned back, fixed into the gap so formed. This procedure has the advantage of not cutting off

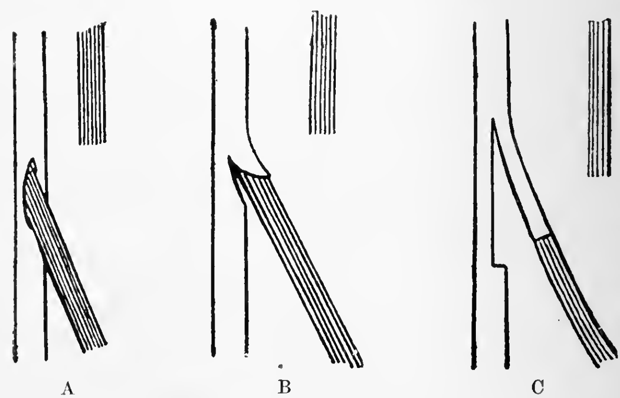

Fig. 366.—Complete Peripheral Nerve Anastomosis, showing the three methods of union. The affected nerve is shaded. A, Insertion of peripheral end of affected into vertical slit in sound nerve. B, Insertion of peripheral end of affected nerve into a gap in the sound nerve, produced by an oblique incision. C, End-to-end union, with flap raised from sound nerve (J. Sherren).

some of the muscles from their nerve-supply. Or, the healthy nerve may be completely divided, and its own peripheral end, as well as that of the paralysed nerve, sutured to the central end. The advantages gained by this proceeding are:—

1. It gives all the fibres of the proximal nerve a chance of branching, which is impossible without dividing it, and the result is that a greater number of the muscle-fibres are supplied by nerve-filaments.

2. It avoids the interruption of conductivity in certain of the nerve-fibres in the healthy trunk, caused by the mechanical implantation of the paralysed nerve.

A full study of Kilvington's important articles, already referred to, should be made before any operations are carried out on the popliteal nerves. During the year 1905 the present writer performed two operations for paralytic calcaneus.[1] The nerve-branches supplying the gastrocnemius and soleus were sought, and identified by faradic stimulation. They were then separated from the internal popliteal nerve and grafted into the external. These cases were successful, so far as some recovery of movement of the soleus and gastrocnemius was concerned.

CASE 19. *Paralytic Talipes Calcaneus, due to Anterior Poliomyelitis; Nerve-Grafting; Partial Recovery.*—W. T., aged 9 years, was admitted into Westminster Hospital on May 19, 1905, under my care. He had an attack of anterior poliomyelitis, when aged $2\frac{1}{2}$ years. He had been

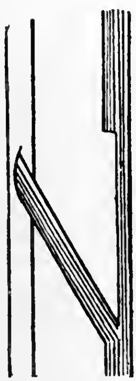

FIG. 367. — Partial Peripheral Anastomosis. It can also be carried out by the methods B and C, Fig. 366 (J. Sherren).

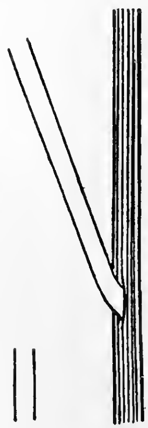

FIG. 368. — Complete Central Anastomosis. It can also be carried out by methods B and C, Fig. 366 (J. Sherren).

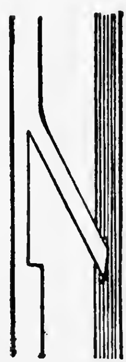

FIG. 369. — Partial Central Anastomosis. It can also be carried out by the methods B and C, Fig. 366 (J. Sherren).

treated by massage and electricity for three years previously to being seen by me.

Examination showed total paralysis of the gastrocnemius and soleus. On June 5, 1905, the internal and external popliteal nerves were exposed. The branches of the gastrocnemius and soleus from the internal popliteal nerve were identified, separated from this nerve-trunk, and grafted into the external.

On October 1, 1905, it was noted that voluntary extension of the ankle had commenced, and the tendo Achillis was felt to become tense during this movement. The power of plantar flexion of the foot steadily increased. When he walked, he could raise the heel from the

[1] *B.M.J.*, March 3, 1906; also *Lancet*, Sept. 1909, and *Trans. XVI. Internat. Med. Congress*, 1909.

ground. At the date of writing, the gastrocnemius and soleus on the left side have not recovered power sufficiently to enable him to raise the whole weight of the body by their efforts, but they are quite active.

CASE 20. *Paralytic Talipes Calcaneus, due to Anterior Poliomyelitis; Nerve Grafting; Partial Recovery.*—Frank R., aged 9, was admitted into Westminster Hospital on the 21st of October 1905, suffering from talipes calcaneus due to anterior poliomyelitis. He had been treated by massage and electricity for the previous three months, with no improvement whatsoever, and the foot was in a position of marked talipes calcaneus, with great contraction of the plantar fascia. The electrical re-actions showed that all the muscles of the left leg below the knee re-acted to faradism, except the gastrocnemius and soleus.

On November 13, 1905, an operation, precisely similar to that performed in the preceding case, was carried out. On December 5 it was noted that there was some tension in the tendo Achillis when voluntary movement was attempted, and on January 9, 1906, he could raise the heel, and the tendo Achillis could be felt to harden when resistance was opposed to the foot. On January 31, 1906, the voluntary movement of the heel upward was more marked.

On May 9 it was noticed that he could flex and extend the left ankle well, when the foot was off the ground. On March 13, 1907, it was found that the gastrocnemius and soleus re-acted to the faradic current, while with the galvanic current K.C.C. > A.C.C. When the foot was plantar-flexed, it required a considerable effort on the part of the observer to overcome the contraction of the gastrocnemius and soleus, and the tension of the tendo Achillis was very considerable. The range of ankle-movement had become almost normal, and, although he was not able to raise the whole weight of the body on the affected foot, the heel was well raised in walking.

In this case the improvement has been continuous, both in the strength of the muscles and the mode of walking, but there is still room for further recovery of the muscles.

Two cases were operated on for paralytic equino-varus, and the distal end of the external popliteal was inserted into the internal popliteal nerve, but so far the result cannot be reported as satisfactory.[1]

CASE 21. *Talipes Varus due to Anterior Poliomyelitis; Nerve-Anastomosis; Failure.*—F. S., male, aged 7 years, was admitted September 17, 1905, with talipes varus dating from the age of 2 years, affecting the left leg. The left leg was wasted and there was loss of power below the knee,

[1] Reported in *Lancet*, Sept. 1909, and *Trans. XVI. Internat. Med. Congress*, 1909; cf. also an instructive paper by Warrington and Murray, "On the Failure of Nerve Anastomosis in Infantile Palsy," *Lancet*, April 2, 1910, p. 912. They suggest there may be sufficient nerve-cells left to supply one group of muscles, but insufficient to supply two.

particularly marked in the peroneal muscles, which gave the re-action of degeneration.

On July 3, 1906, after prolonged treatment by massage and electricity, an operation was performed. The external and internal popliteal nerves were dissected out. The external nerve was then divided completely across, and both the distal and proximal ends inserted into the internal popliteal nerve at a distance of about one inch from each other.

In this case no improvement has followed, being doubtless due to the fact that considerable degeneration had already taken place in the internal popliteal nerve-trunk. A fuller recognition of this fact would have prevented any attempt at nerve-grafting.

CASE 22. *Paralytic Talipes Equino-varus of Poliomyelitic Origin; Nerve-Grafting; Partial Regeneration.*—In a boy aged 8 years, the paralysis dated from the age of eighteen months. It was found, on testing the muscles, that the anterior tibial and the peroneal muscles were completely paralysed and showed the re-action of degeneration.

By way of treatment, preliminary to nerve-anastomosis, the plantar fascia and tendo Achillis were divided. On July 31, 1905, a nerve-anastomosis operation was undertaken in the popliteal space. The internal and external popliteal trunks were exposed, the external one divided completely across, and its distal end inserted into the internal.

No improvement was noted for two years, and then a second operation was undertaken in May 1908 for the purpose of ascertaining the condition of the anastomosed nerve. It was then seen that the distal portion of the external popliteal nerve, below the site of anastomosis, was undergoing regeneration, as evidenced by an increase in size as compared with the proximal part, and by its whiteness, roundness, and firmness; and it was further found that faradic stimulation of this distal portion caused contraction of the anterior and external group of muscles.

In this instance the process of regeneration is extremely slow, but the outlook is hopeful.

In a case of infantile paralysis of three years' duration, affecting the tibialis anticus muscle, J. K. Young [1] located the nerves to that muscle, divided them, and inserted them into slits in the musculo-cutaneous nerve. Eighteen months afterwards, all the muscles of the anterior tibial region gave a good re-action to a slowly interrupted faradic current, but the re-action of the tibialis anticus was fainter than that of the others. Still, its movements could be detected by the hand.

F. E. Peckham [2] has done two cases of nerve-anastomosis for peroneal paralysis. An improvement was noticed in both cases in two or three months.

[1] *Amer. Jour. of Orth. Surgery*, August 1904.

[2] *Ibid.*

Basil Kilvington,[1] speaking of the application of nerve-anastomosis to the treatment of infantile paralysis, says :—

"The opinion, now held, seems to be that it is only in cases of anterior poliomyelitis, where the muscles supplied by a single nerve are paralysed, and where the adjacent nerves are uninvolved, that nerve anastomosis is justified. It has rather a limited field. None of my three cases were favourable ones, and I do not think, at present, I should advise exactly similar ones to submit to the operation. One of the principal sources of failure [2] I take to be the absence of any wound-fibres growing into the paralysed nerve, and keeping up the nutrition of its muscles. In infantile paralysis there is no lesion of the nerve trunk, where the fibrous sheath is torn, to allow of these wound-fibres growing in."

Technique of Nerve-Anastomosis

When a new procedure is introduced, its justification largely depends upon the selection of suitable cases and a keen determination to avoid possible sources of fallacy. Therefore, before we decide upon so radical an operation as nerve-anastomosis we must be sure that the paralysis is not amenable to other measures. To take an example—anterior poliomyelitis. Muscles which appear to be hopelessly inert will, under appropriate treatment, show signs of recovery. By appropriate conditions we mean rest, relaxation of tension thrown upon them by secondary deformity, massage and electricity. Therefore, it may be definitely laid down that no case of paralysis is suitable for nerve-transference, until the usual remedial means just indicated have been continuously carried out under skilled observation for at least six months, and until it is quite clear that faradic excitability of the muscles is entirely lost. It is impossible, when a case first comes under observation, to forecast what amount of recovery will take place with electrical and mechanical treatment. The writer has many times taken cases into hospital which appeared to be eminently suitable for operation on the nerves, but after three months' systematic treatment it was found that such a degree of recovery had taken place as to render

[1] *Intercol. Med. Jour. Australia*, "Lecture on the Surgery of the Nerves," Nov. 20, 1900.

[2] Cf. "On the Failure of Nerve-Anastomosis in Infantile Palsy," by W. B. Warrington and R. W. Murray, *Lancet*, April 2, 1910, and the rejoinder to, with criticism of their article, by A. Stoffel, *Lancet*, Sept. 10, 1910, p. 799. Stoffel gives reasons which may account for the failures in Messrs. Warrington and Murray's cases.

interference with the nerves unnecessary. In the instances related, all sources of fallacy of the nature just alluded to were avoided.

The usual strict aseptic precautions should be observed, and it is important to avoid hæmorrhage, especially from small vessels, as it obscures the parts and renders nerve-branches difficult to identify. Delicate instruments are necessary when the nerves are operated upon. Those used by ophthalmic surgeons serve very well. Fine-toothed forceps are the best for handling the parts; whole thickness of the nerve should never be compressed, the forceps merely steadying it by taking up the epineurium. Sharp knives are always preferable to scissors, as the latter bruise the axis cylinders and cause delay in recovery, and possibly failure of the operation. Temporary silk sutures may be used for steadying the nerves; it is better, however, not to use this material for permanent sutures, as it acts as a foreign body, and may give rise to trouble, months afterwards. Sterile catgut is the best suture material, and it is not necessary to use specially hardened gut. The Van Horn catgut, hardened to resist absorption for ten days, may be employed, if there is tension on a stitch. The suture should be passed with a round needle, both being as small as possible.

When one nerve is inserted into another, the insertion is made as nearly as possible in the long axis of the receiving trunk. Sherren [1] recommends that the suture should be passed through the whole thickness of the nerve at right angles to its axis, and tied with just sufficient force to bring the ends into apposition. Personally, I prefer two epineurotic sutures in the long axis of the trunks, drawing them together in close contact. When one nerve is inserted into another, the receiving trunk must be sufficiently opened up. It is well to insert the knife until a little white material exudes, thus showing that the epineural and perineural sheaths have been ruptured, and then the aperture is ready to receive the graft.

Ingrowth of fibrous tissue between the nerve-ends, or adhesion of the junction to the surrounding parts, must not occur. Wound infection is fatal to success, hæmorrhage is to be prevented, and the nerve-junctions must be protected from matting together. Cicatrisation is absolutely inimical; and is best avoided by wrapping sterilised chromicised cargile membrane [2] around the junction.

[1] *Injuries of Nerves*, London, 1908, p. 76.

[2] We find that cargile membrane, hardened so as to withstand absorption for ten days, is the best material for this purpose.

Accurate apposition is essential, and too much care cannot be bestowed upon passing and tying of sutures. A suture, which compresses axis cylinders, will cause their degeneration.

We have seen that in tendon-transplantation it is of the utmost importance to remedy secondary deformities, and it is also of great assistance to lengthen the contracted antagonists of the paralysed muscles. It therefore follows that both these essential details should be attended to before nerve-anastomosis is entered upon. In one of the author's cases of talipes equino-varus, although the secondary deformities were remedied, yet the powerful antagonists of the paralysed muscles were not thrown out of action by tenotomy before the nerve-anastomosis was done, and this may have accounted for the unsuccessful result.

Dr. Alfred S. Taylor has contributed a paper to the *Amer. Jour. Orth. Surg.* vol. vi., Nov. 1908, pp. 210-220, entitled, "A Contribution to the Surgery of the Peripheral Motor Nerves." After describing the types of suture, he says, "The simple implantation of the paralysed nerve into a longitudinal slit in the sound nerve gives very satisfactory return of motor-power, and causes the minimum of disturbance in the muscle-field of the sound nerve. It should be the method of preference." Writing on the technique, Dr. Taylor remarks that "in all cases, where the sutures will be subject to tension, fine silk (0 or 00) should be used, because of its reliability. If the suture be coated with vaseline, it will cause the minimum of traumatism to the nerve-tissues. On each side of the nerve, about $\frac{1}{8}$ to $\frac{1}{4}$ of an inch from its divided end, a suture is passed transversely through enough of the sheath to give a good hold, and is tied, leaving the ends long. The other nerve is treated in the same way, and the two ends are approximated by tying together the corresponding pair of sutures. For lateral implantation, the nerve-end is trimmed to a wedge-shape and sutures placed as above. One end of each suture is then passed through its side of the longitudinal slit in the other nerve, and as the sutures are tied, the wedge-shaped end of the one is drawn into the slit of the other and snugly held there. The wedge-shaped end gives the greatest axis cylinder contact. . . . The nerve-sheath should always be trimmed sufficiently to prevent it from crowding on to the nerve-junction and hindering re-union." "The first evidence of nerve-regeneration appears in improved sensory and trophic conditions. These are very variable in the time of their onset, but they are usually well advanced by the end of three months. Voluntary motion, except in a few unexplainable instances,[1] never returns sooner than three months after operation, and often only after six to fifteen months have

[1] Cf. the author's case of facial paralysis, p. 747, where the return of power occurred within a week of the operation.

passed."[1] Taylor gives five cases of nerve-transference for talipes; except in one case, no good result followed.

Indications for and against Nerve-Anastomosis

The varieties of cases which are unsuitable are of three kinds:—

1. Where a large amount of recovery has taken place and the limb is fairly useful.

2. Where extensive destruction of muscular tissue has occurred, and the degree of muscular atrophy is great.

3. Where paralysis of a large nerve-trunk exists, and a small nerve only is available as a re-inforcer. It is unreasonable to expect a nerve, such as the musculo-cutaneous, to innervate the muscles supplied by the internal or the external popliteal nerve.

It is difficult to know the exact period during which the muscle, whose nerve is paralysed, is capable of spontaneous recovery. Most neurologists think that the period is not longer than two years, but Hackenbruch's case of recovery of the facial nerve, by means of nerve-anastomosis, seven and three-quarter years after the onset of paralysis, is against this view; and my cases of talipes calcaneus, where paralysis had existed for seven and for six and a half years, respectively, and some recovery took place, strongly support Hackenbruch's opinion.

J. Koch[2] stated that when the fatty degeneration is scattered throughout a muscle in small areas, a large amount of regeneration of muscular fibres may take place; but when the entire muscle has been transformed into fat no such regeneration can take place. It is in these partially degenerated muscles that we must look for the best results of nerve-anastomosis.

It is highly important, if possible, to select synergic nerves, such as the median, to re-inforce the ulnar or *vice versa*, rather than to use opposing nerves, such as the musculo-spiral and median; and, for this reason, that with antagonistic nerves, although the coarser movements may be regained, yet it is doubtful if the finer co-ordinated movements ever re-appear. Experience, however, shows that there is greater probability of the latter taking place in younger than in older subjects.

[1] In our cases of nerve-transference for infantile paralysis the earliest date was three months. It was striking to observe that return of movement was present for at least a month before any change in the electrical re-action took place.

[2] *München. med. Wochenschr.* July 1904.

Before nerve-grafting is undertaken, the paralysed nerves and muscles are most carefully tested electrically, and a very thorough analysis made, as otherwise there is a risk of healthy nerve-tissue being sacrificed. With regard to electrical testing, especially in the case of a child, it should be done not only whilst the patient is conscious, but also under an anæsthetic, when stronger currents can be used. The operator should make sure that he is not dealing merely with a wasted and atrophied muscle, but that it is paralysed. A course of electrical treatment of two or three months will settle this question. If the muscle fails to show even a flicker during that time, it is paralysed.

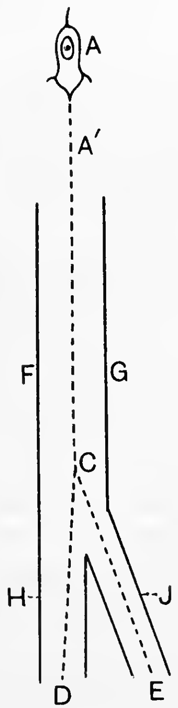

Fig. 370.—To illustrate the Axon Reflex Phenomenon. A, motor-cell in anterior cornu of spinal cord; FG, great sciatic nerve; H, internal popliteal nerve; J, external popliteal nerve; A′C, nerve-fibre, dividing at C into two branches D and E, conveying antagonistic motor impulses (Kilvington).

Before operating, we have to consider how far the operation is justified. It is a bold procedure to cut a paralysed nerve and implant its peripheral end into a sound one, and it is still bolder to cut a slip from a healthy and important nerve. We should carefully consider what is the effect of these procedures on healthy and paralysed muscles. Again, we must think of the possibility of the appearance of inconvenient associated movements, such as occur in facio-accessory anastomosis.

The crux of the whole matter is: Can a muscle which has been brought to life by this operation learn to functionate independently? In proof of this we have Kennedy's experiments and the operative results of several surgeons. Another important point is that we must avoid the sacrifice of healthy nerve-fibres or of sensory nerves, and therefore we must learn as far as possible the exact position of the various bundles of fibres in a large nerve-trunk.[1] In some instances, such as the popliteal and sciatic nerves, the branches of the various muscles and the sensory fibres can be traced for a long distance in the trunk, and isolated

[1] The topography of the cross-section of nerves has been worked out by A. Stoffel, *Deutsch. Zeitschr. für orth. Chir.* Bd. xxv.

PLATE XXXIII.

Skiagram of the Trunk of a patient, aged 6 years, suffering from Kypho-Scoliosis, due to Anterior Poliomyelitis, under treatment at Westminster Hospital.

To face page 671.

without damage. Such a proceeding was carried out by the author in two operations for talipes calcaneus. Following Harris and Low, he has also shown that the fibres of the deltoid run in the upper and outer part of the fifth cervical nerve-root, and those of the biceps in the lower and inner part.

In performing lateral anastomosis of nerves, raw surfaces are required, and it is futile to lay one large nerve by the side of another, as the axis cylinders cannot penetrate the tough perineurium and epineurium. It is also better to use a large central end, such as that of the internal popliteal, to innervate one or more distal ends, in preference to a smaller one, such as the external popliteal. In a large nerve-trunk there are more fibres in the central portion to form branches, which will penetrate the distal nerve-trunks.

Finally, the possibilities of an operation proving futile, owing to the "axon reflex phenomenon," which arises from branches in the central nerve-end passing to antagonistic distal trunks (Fig. 370), must not be forgotten, and Kilvington's valuable suggestions on this point [1] are well worthy of careful perusal.

There is also this to be said in justification of nerve-anastomosis, that if it fails, especially in cases of infantile paralysis, we still have at our disposal muscle- and tendon-transplantation and arthrodesis. In fact, looking forward to the not very remote future, we shall find that the best results of nerve-anastomosis, as of tendon-transplantation, will be obtainable by judicious combinations, previously applied, of tenotomies, to throw out of action for a time and lengthen the powerful antagonists; by shortening weak and relaxed tendons on the paralysed side of the limb; by arthrodesis, to steady important and weight-bearing joints; and by excision of oval portions of superficial tissues to assist in maintaining correction of the deformity.

The author attributes his partial success only in the talipes calcaneus cases, to the fact that he expected too much of the nerve-transference. If he had rendered the foot firm and stable, and reinforced the ankle and astragalo-calcaneal joints by artificial ligaments and other measures before the nerve-operation, the results might have been more gratifying.

We have thus at considerable length critically reviewed all the measures at our disposal in the surgical treatment of infantile paralysis. It remains to indicate their application in the next chapter.

[1] *B.M.J.*, September 16, 1905.

CHAPTER III

THE TREATMENT OF PARALYTIC DEFORMITIES OF THE TRUNK AND LIMBS

Infantile Paralysis of the Spinal Muscles and Paralytic Scoliosis—Paralysis of the Abdominal and Other Muscles of the Trunk—Paralysis of the Upper Extremity—Of the Shoulder, Partial and Complete—Paralytic Dislocation of the Shoulder—The Upper Arm Type of Erb—The Forearm Type of Remak—Paralysis of the Wrist and Hand—Paralysis of the Lower Extremity—Partial and Complete Paralysis of the Ankle, Knee, and Hip.

Infantile Paralysis affecting the Spine: Paralytic Scoliosis

The actual extent of loss of power varies, yet, however slight it may be, the balance of the spine is so delicate that the right line is quickly lost, and first deviation and then rotation with scoliosis set in. The primary curve is always to the weaker side and rapidly assumes extensive proportions. Alterations in the shape of the chest and the trunk soon make their appearance.

Paralytic scoliosis is a most intractable form, when it is once thoroughly established. In all instances of paralysis of an arm or a leg on the same side, particular attention should be paid to the spine from the first, and massage and other muscular stimuli should be assiduously used daily. It is noteworthy that, whilst rapid recovery often takes place in the arm and leg, some residual paralysis remains in the back, and, if untreated, it results in severe deformity. A point which should be emphasised is that it may come on some time after the patient is apparently cured, and therefore calls for special observation and examination.

The alterations in tension on the part of the erector spinæ and other muscles, permit dropping of the pelvis on the affected side and often extreme tilting, so that there is great apparent lengthening of the lower extremity.

Treatment.—In the earlier stages of paralytic scoliosis every effort should be made to limit the deformity by physiological methods; when, however, it is present, it is essential for the patient to wear a form of spinal support; and indeed these cases are amongst the few instances of scoliosis where supports can be unhesitatingly recommended. Despite, however, these extraneous aids it often happens that the spine continues to incline. In any case the outlook is very unsatisfactory, and it is sometimes necessary to continue the support from the lower extremity right up to the axilla, so as to counteract the tendency of the trunk to fall towards the paralysed side.

FIG. 371.—Saddle-Back deformity, due to affection of the spinal muscles by anterior poliomyelitis (Bradford and Lovett).

In some instances of paralytic scoliosis where the deformity advances in spite of treatment, we have arrested the deformity and even obtained some recession of it, by extending the patient fully in the prone position on a suitable couch. By manual pressure on the points of greatest deformity of the ribs and by prolonged extension we have often observed an improvement in the curve and in the outlines of the trunk. The body is then enclosed in a plaster of Paris jacket, which is kept on for three months or more. At a second sitting, further improvement can be obtained. It is almost useless, in most of these cases, to trust to massage and exercises alone, if the paralytic condition is at all marked. The influence of habitual posture and the effects of loss of balance cannot be entirely counteracted by physiological methods. Another method we have employed, with beneficial results, is continued suspension of the trunk in a spinal chair. The traction is effected by head and axillary slings attached to an overhead support, and the degree of upward traction is such that the hand can be passed between the gluteal region and the seat with a little difficulty. The patient should not be lifted quite clear of the seat of the chair.

Paralysis of other muscles of the *trunk* occurs. Thus the abdominal muscles may be affected, and when the weakness is bilateral, the patient, on standing, has a typical lordotic attitude. Sometimes one rectus only is affected; and if we mistake not, a case has been described by our friend and colleague, Mr. Jackson Clarke, which was associated with scoliosis. So capricious is anterior poliomyelitis that any muscle may be attacked, and so extensive is its distribution that nearly all the muscles of the neck, chest, and abdomen may be helpless, at any rate during the height of the attack.[1] Residual paralysis of the erectores spinal muscles causes severe kyphosis—inability to sit upright. In crawling, the saddle-back deformity is seen (Fig. 371).

Treatment of Infantile Paralysis of the Upper Extremity

We have already alluded to the necessity of distinguishing deformity due to the loss of power in certain muscles from that which arises from contracture of opposing unaffected muscles, gravity and habitual posture. In no part of the body except the foot is this so well illustrated as in the case of dropped wrist. Here the extensors are paralysed and the flexors become structurally shortened. This shortening is aided by gravity.

We have also insisted upon this axiom, that apparently paralysed muscles do not show signs of recovery until tension is taken off them and they are completely relaxed.

The principle then that should guide us in the treatment of deformities in the upper extremity, as elsewhere, is to obtain relaxation or relief of tension of the weakened muscles, either by mechanical or operative treatment; and then to use such restorative methods as electricity, massage, tendon-transplantation and nerve grafting.

In *The Surgery of Paralyses*, p. 54 *et seq.*, several instructive

[1] Cf. Sachs, "The Present Day Conception of Acute Anterior Poliomyelitis," *Amer. Jour. Orth. Surg.* vol. vi., Nov. 1908, p. 179.

cases are given, illustrating how successful the carrying out of this principle is in dealing with dropped wrist. We must now deal with the various types and forms of paralysis in the upper extremity.

Complete Paralysis of the Upper Extremity.—For this extremely rare condition no treatment is available. Shoulder, elbow and wrist are flail-like, and the arm is fully extended. Sometimes, however, contraction of the wrist is seen, a fact tending to disprove a current theory, which states that paralytic deformities are frequently induced by the involuntary contraction of unparalysed muscles (cf. Fisher, *Intractility of Muscle*, Vol. II. p. 607). Contraction of the elbow rarely occurs, as it always swings freely, yet the fingers are flexed, because this is their normal condition when left hanging, as may be confirmed under an anæsthetic. The weight of the fingers is not sufficient to keep them extended.

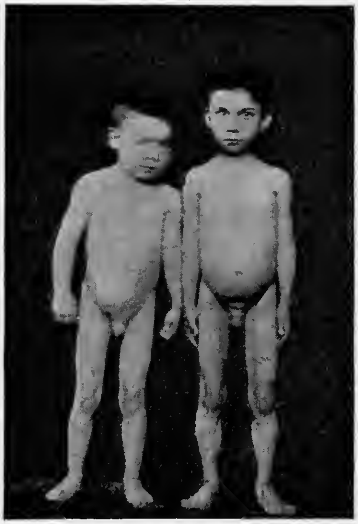

FIG. 372.—Erb's Paralysis of the Upper Extremity. Note the position of the hand in the figure on the left (Purves Stewart).

Paralysis of the Deltoid, Supra- and Infra-spinatus, Biceps and the Supinator Longus (the upper-arm type of Erb).—Here the shoulder hangs flail-like, and the elbow is nearly completely extended (Fig. 372). It is important, if possible, to restore two movements, namely abduction at the shoulder-joint and flexion at the elbow; of these the latter is the more important. In general, the arm should be kept in a sling or halter, with the elbow at an angle of flexion of somewhat less than 90°, the wrist and hand being hyperextended on a malleable iron splint. In order to aid the recovery of the deltoid, a malleable iron splint, bent at an angle of 75°, is fixed, one limb of it to the trunk, and the other limb beneath the arm to support it; that is to say, the affected muscle is relaxed. It is also constantly kneaded, massaged and electrified, and especial care is taken not to permit full extension of the elbow to take place.

We may, however, at first concentrate our attention on the biceps, and if even a trace of power is discovered in it, treatment may be tried for eighteen months or two years, and in many instances a successful result follows. If the sling is removed too soon, the biceps will be stretched again, and for a few weeks will not respond to any voluntary effort. The clinical test of recovery of the biceps is the power of voluntary movement of the forearm from its temporary flexion-angle to a point near the chin. The test of recovery of the extensors of the wrist is the power to hold the hand in a hyperextended position, when the splint is removed. The arm and hand must be secured at night-time even when recovery appears to be satisfactory, and restraint during the day should be cautiously removed.

If no recovery takes place in the biceps and the deltoid under this treatment, we must decide whether to resort to (*a*) nerve-anastomosis or (*b*) muscle-transplantation. In all instances it is advisable to operate on the brachial plexus first.

In the general notice on nerve anastomosis we have alluded to a case of infantile paralysis which had been treated by identifying the fibres in the fifth nerve cord going to the deltoid and biceps, and then taking a slip from the distal part of the nerve trunk, and inserting it into the sixth nerve cord. The following cases operated on by the author may be referred to here.

CASE 23. *Nerve-Anastomosis for Erb or Upper Arm Type of Infantile Paralysis.*—N.T., male aged nine years, came under observation on November 21, 1906, with the history of an attack of infantile paralysis in September 1906, which resulted in partial loss of power in the left arm. He was seen by me on November 21, 1906. The left arm hung by the side, but the elbow and wrist could be flexed. The deltoid, supra- and infra-spinatus, the biceps and supinator longus were wasted and did not respond to faradic stimulation. He could flex and extend the elbow, however, with the remaining muscles, attached to the internal and external condyles. He was treated by massage and the constant and faradic currents, but no improvement followed.

On May 22, 1907, the condition of paralysis remained *in statu quo ante*; and it was decided to graft the anterior branch of the fifth cervical nerve into the sixth. This was done on May 27, 1907. The fifth cord was divided, and both its proximal and distal ends inserted into the sixth about half an inch apart. Massage and the faradic and constant currents were used daily. No improvement was observed for a year. On May 20, 1908, it was noted that contraction had appeared in the biceps, and the muscle was fuller and firmer; also that the posterior part of the deltoid was active, and the fibres were developing. On May 14, 1909, the improvement in the biceps was seen to be steadily continuous though slow, and the deltoid was firmer and more active.

CASE 24. *Infantile Paralysis of the Deltoid Muscle: Nerve-Anastomosis.*—Sidney G——, aged twelve years, was admitted into Westminster Hospital in 1906 with paralysis of the right deltoid. At the age of ten years he had an illness, and afterwards he was unable to abduct the arm. Massage and electricity had been used without any result for the three years before he came under our observation. The deltoid was entirely wasted, and utterly failed to respond to any faradic stimulation. It was decided to perform a nerve-anastomosis. The brachial plexus was exposed, and, assisted by Mr. E. Rock Carling, the writer determined by means of sterilisable electrodes which portion of the fifth nerve-cord was paralysed. It was found that a weak stimulus, applied to the internal portion of the cord, caused contraction of the biceps, supinator longus and extensor carpi radialis longior, but when the current was applied to the outer portion of the cord no effect was observable. From this we concluded that the fibres supplying the deltoid lay in the upper and outer portion of the cord. It was therefore divided half-way through its thickness and then longitudinally downwards for an inch, so that the nerve fibres of the deltoid could be brought over to the sixth nerve cord. Into the sheath of the latter a longitudinal incision was made, and the free end of the slip of nerve-fibres from the fifth inserted and sutured.

Twelve months after the operation, the deltoid responded to faradic stimulation. The muscle had increased in size, had become firm, and could be felt to harden when voluntary movement was attempted. Eighteen months after the operation, the boy could abduct the limb six inches from the side, and two years afterwards about eight inches.

Since then the boy has been lost sight of, but from the experience of the previous case we have reason to believe that the recovery will be continuous.

If nerve grafting fails, we can revert to muscle-transplantation. The author planned and carried out an operation for restoring the action of the biceps.[1] It consists of taking a slip of muscle from the triceps (Figs. 373, 374). The lower part of its outer head is separated from its distal attachment, brought forward and inserted into the lower part of the biceps, the elbow being held at the time fully flexed. In the first case, that of a carter aged fifty-seven years, who had paralysis of the biceps and deltoid from a fall on the shoulder, the patient was able to flex the elbow fully after two months. In three other cases, in which the operation was performed for infantile paralysis, the action of the biceps was replaced either partially (Figs. 375, 376, 377) or entirely, and so far this particular

[1] *Clin. Soc. Trans.* vol. xxxv. p. 181.

operation has yielded as good, if not better, results than nerve anastomosis.[1]

The problem of making a new deltoid is more difficult. The writer first attempted to do so by using the clavicular portion of the pectoralis major. The free end of the latter muscle, about six inches in length, was brought over the acromion, carried down the

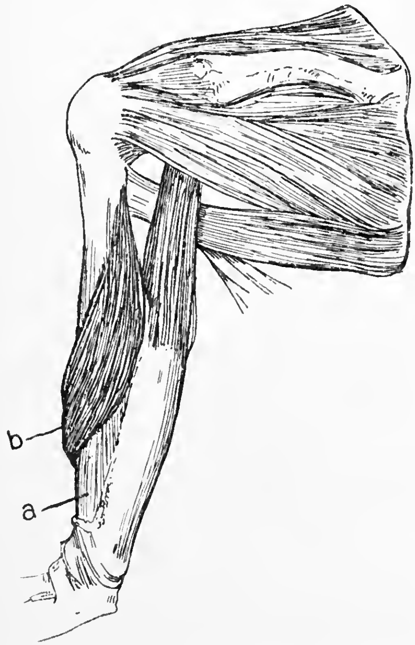

FIG. 373.

FIG. 374.

FIG. 373.—To illustrate the author's operation of transferring the Attachment of the Outer Head of the Triceps Humeri into the Biceps for Paralysis : *a*, humeral attachment of outer head of triceps ; *b*, outer head of triceps carried round the outer edge of the humerus.

FIG. 374.—The completion of the operation : *a*, the outer head of the triceps, brought forward and inserted into the biceps at *b*.

arm and firmly fixed into the wasted deltoid, the upper arm being fully abducted. As it passed over the acromion, the transferred pectoralis major was secured to the bone by one silk suture. The result in the case of this heavy man was not successful, although he acquired a better fixation-point at the shoulder-joint for the movements of the arm.

[1] Robert Soutter, *Amer. Jour. Orth. Surg.*, Nov. 1908, p. 199, has transferred a portion of the pectoralis major into the biceps.

Fig. 375.

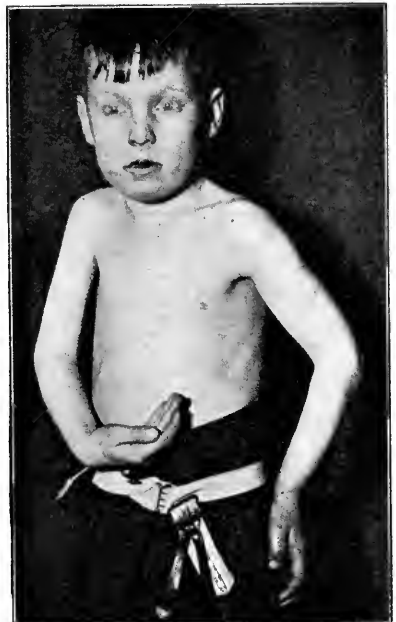

Fig. 376.

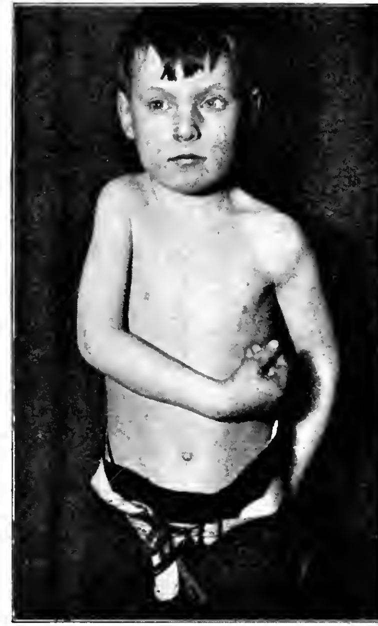

Fig. 377.

Three figures illustrating one part of the Treatment of the Paralysis, arising from poliomyelitic affection of the fifth and sixth anterior cervical nerves, by Transferring the Outer Head of the Triceps into the Paralysed Biceps.

Fig. 375.—The helpless condition of the Right Arm before the operation.
Fig. 376.—Commencing Return of Power of Flexion of the Elbow, three months after the operation.
Fig. 377.—Continued Increase of Power of Flexion of the Elbow, six months after the operation. Further improvement followed.

In the cases of two children, suffering from infantile paralysis, the results were better, in so far that about 15° of abduction were secured.

The writer, independently of and previously to Hoffa, to whom the credit of the operation is usually assigned, employed the trapezius as a substitute for the deltoid, using the clavicular part of it. The

FIG. 378.—Paralysis of the Left Deltoid Muscle, showing the Elevation of the Shoulder, when the patient attempts to abduct the arm (Royal Whitman).

operation consisted of separating the distal part of the clavicular portion of the pectoralis major, then uniting it with the clavicular part of the trapezius, and the new muscle mass, so made, was inserted as low down on the outer aspect of the humerus as possible, so as to replace the atrophied deltoid.[1] The shoulder-joint was thus

[1] Otto Kiliani, *Ann. Surg.* Jan. 1910, pp. 79-83, has introduced an original feature. He brings the head of the humerus into contact with the glenoid, in paralytic dislocations, by pleating the long tendon of the biceps. E. H. Bradford, *Amer. Journ. Orth. Surg.* vol. viii. No. 1, 1910, p. 23, operates as follows: "An incision is made over the middle region of the deltoid, passing well above the shoulder, and down toward the deltoid insertion; the insertion of the trapezius along the acromion is freed at a sufficient distance from the point of insertion, and a silk strand quilted into

rendered more stable and a few degrees of abduction secured. So far as the experience of the writer goes, nerve-anastomosis for deltoid paralysis is more helpful than transplantation of the muscle.

FIG. 379.—Illustrating the improvement in the range of abduction, obtained by Transplantation of the Trapezius Muscle. The line of the incision is shown (Royal Whitman).

Paralytic Dislocation of the Shoulder-Joint.—The forms of paralysis which give rise to this lesion are anterior poliomyelitis, palsy of the brachial plexus after injury, spastic paralysis, in which

it. These strands are seized by long forceps and passed under the skin ; by means of a small incision the strands are made to emerge at the point of the deltoid insertion, or at such point in the humerus, as may be desired. The silk strand is quilted well into the periosteum at the front of the deltoid insertion, and the silk strands tied, the arm being raised to its highest point. A second small incision is then made along the inner border of the scapula at the level of the spine, a portion of the trapezius is isolated, and, by means of the silk strand, quilted into the periosteum along the proximal end of the spine and the adjacent portion of the scapula." Great care is required in keeping the arm elevated for many weeks subsequently.

contraction of the pectoralis major is very marked, obstetrical paralysis, wasting of the deltoid after separation of the upper epiphysis of the humerus, and injury to the circumflex nerve during birth.

The condition may originate at any time from birth onwards, and the state of the parts will be found to vary with the duration of the disability and the cause. In old-standing cases the bony landmarks are very prominent, and the outline of the shoulder is angular. The head of the bone is separated by a groove from the overhanging acromion process, and if the capsule is very lax this hollow is strongly marked.

The disability resulting from this lesion is so variable that no general description applies to it.

Treatment.—This will largely depend upon the causation. In a case of injury to the brachial plexus, whether traumatic or obstetrical, the site of the nerve lesion must be discovered, and operative treatment directed to it. In infantile paralysis, if all the muscles acting on the shoulder-joint are involved, and some of the muscles moving the elbow, wrist and hand are sound, the best form of treatment is an arthrodesis of the shoulder-joint (p. 653.) By affording a point of fixation for the movements of the lower segments of the limb, the capabilities of the member are greatly increased. While on this subject, we may refer to a class of similar cases, some of which are due to paralytic causes and some are not.

Paralytic Dislocation and Recurrent Dislocation of the Shoulder.—It is stated that the causes of habitual dislocation of the shoulder are :—

1. Laxity of the capsule of the joint after traumatic dislocation.
2. Partial fracture of the head of the humerus.
3. Fracture of the glenoid cavity.
4. Tearing away of muscular insertions and rupture of tendons.
5. An abnormally-shaped head of the humerus, not demonstrably due to fracture.
6. Paralysis of the muscles about the shoulder-joint, especially the deltoid.[1]
7. Syringomyelia.

Zesas states that, whilst in tabetic joint affections, dislocations,

[1] Paralysis, wasting and secondary dislocation must not be confounded with traumatic dislocation of the joint, with subsequent wasting and injury.

partial or entire, are met with chiefly in the lower extremities, in syringomyelia the joints of the upper extremity, especially the shoulders, are those usually involved. He says this is an early sign in syringomyelia, and is of diagnostic importance. There are, however, many other features present in syringomyelia, notably the associated anæsthesiæ, which serve to distinguish it from tabes.

Treatment.—Reduction is by no means always easy. Thus in a case, recorded by Witius,[1] of an epileptic whose shoulder-joint was luxated no less than fifty-four times, it was not always possible to effect reduction without an anæsthetic. In many cases, even when a dislocation has been reduced, it recurs on the slightest provocation, but fixation for a long period, with a suitable support, has been tried and proved successful. The support must be removed to permit daily massage in order to obviate muscular wasting, as the greater the wasting, the greater is the liability to dislocation.

The mechanical appliance commonly in use is made of a shoulder-cap, to which is jointed a stem running down the arm, both cap and stem being secured around the chest and humerus by straps (Fig. 266, p. 514).

If after due trial, such measures are unsuccessful, or when dislocation is likely to imperil the patient's life, as in swimming in deep water, or if the means of livelihood are seriously interfered with, the capsule may be shortened by pleating it through an anterior incision. This operation has proved successful in the writer's hands. Some surgeons prefer to excise a portion of the capsule, and then suture. In the operation of suturing the capsule, this structure should be laid bare as widely as possible, so as to ascertain definitely which part is the more lax. Whilst doing so, if it can be demonstrated that any of the tendons have been torn away from their insertions, they should be re-united to the bone.

Other methods which have been occasionally resorted to are: deepening of the glenoid fossa, resection of the joint, and arthrodesis. When the paralytic luxation is complicated by painful neuralgia, the limb may be amputated.

To resume our study of the purely poliomyelitic lesions, we now refer to:—

Paralysis of the Extensors of the Wrist, the Supinators Escaping (the forearm type of Remak).—This form is eminently

[1] *Münch. med. Wochens.*, 1905, No. xxxiii. The history of epilepsy is so often met with in recurrent dislocation of the shoulder, that the disease must be looked upon as directly causative.

suitable for mechanical treatment on the same lines as for dropped wrist. If treatment by mechanical means fails, then tendon-transplantation may be resorted to. The contracted flexor tendons of the fingers are first lengthened by the Z-method, and the flexor carpi radialis and ulnaris are separated from their distal attachments, carried backwards, and fixed to the bases of the second and fifth metacarpal bones. Finding on three occasions that the tendons were too short to reach the desired spots of insertion, the author used

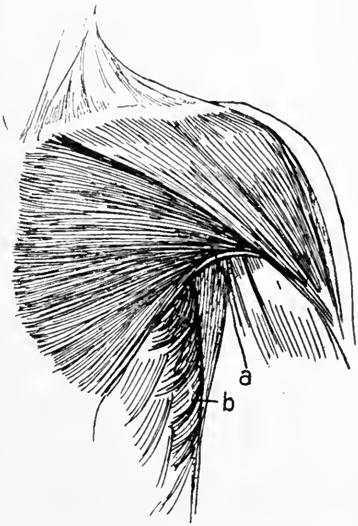

Fig. 380.

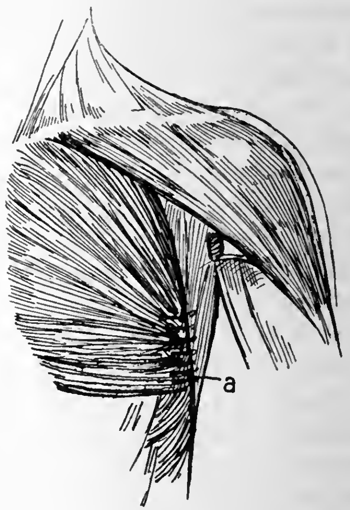

Fig. 381.

To illustrate the author's operation for Paralysis of the Serratus Magnus.
Fig. 380. *a*, sternal portion of pectoralis major ; *b*, serratus magnus.
Fig. 381 shows the sternal portion of pectoralis major detached from its humeral insertion, spread out, and inserted into paralysed serratus magnus.

artificial silk tendons to prolong them. They have been of permanent use, and have not given rise to any trouble, except in one case which developed scarlet fever two days after the operation, and then suppuration followed. In every case, most careful nursing of the part is required after the operation.

Flail Elbow.—When all the muscles of this joint are paralysed or nearly so, the operation advocated by Mr. Jones, Vol. II. p. 625, may be performed. Arthrodesis is not desirable, because, while it fixes the joint, it destroys pronation and supination, and, if any power is left in the pronators and supinators, it is foolish to deprive the patient of these useful movements.

FIG. 382.

FIG. 383.

Two views of a girl, under the author's care in Westminster Hospital, showing Paralysis of the Left Serratus Magnus, due to Anterior Poliomyelitis.

Paralysis of the Interossei.—When these muscles are affected and the extensors have escaped, an operation may be undertaken to replace them. It is founded on a suggestion for treatment in a case, referred to the writer by Sir William Gowers. As the result of a gun-shot wound, residual paralysis of the interossei was the cause of great disability in using the hand. Slips were taken from the extensor communis tendons, just below the metacarpo-phalangeal joints, and inserted into the interossei tendons. Six months afterwards, the power of extension of the last two phalanges of the fingers had markedly improved, but some stiffness of the metacarpo-phalangeal joints remained.

As an example of paralysis of single muscles, we may refer to :—

Paralysis of the Serratus Magnus (*Winged Scapula*).—Paralysis of this muscle alone occasionally exists ; with it is usually combined weakness of the lower part of the trapezius. Winging of the scapula is well marked, the spine of the scapula is more horizontal, its lower angle is nearer the mid-line than the upper, and nearer than the lower angle on the sound side. The patient is unable to raise the affected arm in front of the body above the level of the shoulder, and cannot make any thrusting movements. When he attempts to do so, the scapula stands away from the body. It is also noticeable that the surgeon's fingers can be inserted beneath the internal border of the scapula, and it can be drawn away from the ribs.

So far no operation on the nerves has been undertaken to regenerate the serratus magnus, but the author designed and carried out, with the most satisfactory results, an operation of muscle-transplantation for winged scapula,[1] which consists of using the sternal portion of the pectoralis major (Figs. 380, 381). It is detached from the humerus and from the front of the chest for a considerable distance, and is then carried round the ribs beneath the scapula and inserted into the serratus magnus as far towards the vertebral margin of the scapula as possible, which is drawn at the time well forward. In four weeks time the patient had regained thrusting movements, and the scapula lay as flat on the back of the chest as its fellow (Figs. 385, 386).

[1] A. H. Tubby, *Brit. Med. Jour.*, Oct. 29, 1904.

Fig. 384.

Fig. 385.

Fig. 386.

Fig. 384.—The same patient as in Figs. 382, 383, showing the Line of Incision for the operation of re-inforcing the Serratus Magnus by using the Sternal Portion of the Pectoralis Major.

Fig. 385.—The results of the operation of re-inforcing the Serratus Magnus by using the Sternal Portion of the Pectoralis Major. Note the complete restoration of the thrusting power of the upper extremity.

Fig. 386.—Illustrating the results of the author's operation for Restoration of the Action of the Serratus Magnus. Note the symmetry of the scapulæ when the arms are at rest.

Infantile Paralysis of the Lower Extremity and its Treatment

Whilst in the upper extremity the proximal segments of the limb are quite as often affected as the distal, if not more so, in the lower limb paralysis of the distal segments is infinitely more common; the frequency, with which the parts are attacked, decreases from the foot to the hip. Therefore we will discuss the subject under the following headings and in the following order:—

A. Paralysis, partial or complete, of the ankle and foot.
B. Paralysis, partial or complete, of the knee.
C. Paralysis, partial or complete, of the hip.
D. Paralysis of the whole limb.

A. Paralysis, Partial or Complete, of the Ankle and Foot

In the partial form, some power is left in those muscles which act upon the ankle- and foot-joints. In the complete form, the foot is useless and flail-like.

The deformities which are met with are:—

1. *Talipes Equinus*, due to paralysis of the dorsiflexors of the ankle; and, in describing this form, we must include right-angled contraction of the tendo Achillis and pes cavus, with its degrees of talipes arcuatus and plantaris.

2. *Talipes Calcaneus*, from paralysis of the calf muscles.

3. *Talipes Varus*, due to paralysis of the peronei.

4. *Talipes Valgus*, arising from paralysis of the invertor muscles, especially the tibialis anticus and posticus.

The combined forms met with are: Equino-varus, Equino-valgus, Calcaneo-varus and Calcaneo-valgus.

In *complete paralysis* of the ankle, the common type of deformity met with is talipes equinus, the foot falling into that position mainly owing to the action of gravity.

1. **Paralytic Talipes Equinus.—Causation.** In addition to anterior poliomyelitis, acquired talipes equinus is traceable to peripheral neuritis arising from alcohol and other poisons, and it is also seen in children after infectious illness, particularly diphtheria, scarlet fever, and occasionally measles. In these instances the deformity is rarely severe, and is more usually either pes cavus or else right-angled contraction of the tendo Achillis.

The degrees of equinus, its morbid anatomy, prognosis, and diagnosis, have been dealt with in Vol. I. p. 329.

Treatment of Paralytic Equinus.—(1.) **Preventive.** We feel it incumbent upon us to re-iterate that in recent cases of infantile paralysis and peripheral neuritis every effort should be made from the first to prevent deformity. As a general rule, the flexors of the limbs are less affected than the extensors, and hence the contraction will appear on the flexor aspect of the joints. The effect of this is twofold: it not only causes the limb to assume an abnormal position, but it also over-stretches the already weakened extensor muscles, and so lessens the chances of early recovery. Therefore, the ankle-joint should be kept in a position of equilibrium between flexion and extension, or somewhat dorsi-flexed. A malleable iron splint, bent to a right angle, and placed on the flexor aspect of the leg and on the sole of the foot, answers the purpose admirably (Fig. 333, p. 616).

FIG. 387.—Apparatus for the treatment of Talipes Equinus, after section of the tendo Achillis. In the later stages the bar under the sole is added and the iron removed (Tubby and Jones, *Surgery of Paralyses*).

(2.) **Active Treatment of the Deformity.**—In cases of right-angled contraction of the tendo Achillis, manipulation and exercises may be employed. Manipulation consists of directing the patient to extend the knee fully, and then dorsiflexing the foot passively several times in succession, so as to stretch the tendo Achillis. The best form of active exercise is to direct the patient to plant the foot firmly on the ground and then flex the limb at the knee, taking care not to raise the heel.

FIG. 388.—A simple form of tin-shoe for the treatment of Paralytic Talipes. It is made of two pieces of sheet-iron, suitably bent, and a connecting piece of stout iron-wire (*Surgery of Paralyses*).

A walking-apparatus with a toe-uplifting spring, and an equinus stop at the ankle-joint to prevent undue plantar flexion, is employed by way of after-treatment, whilst the application of a tin-shoe at night is useful. Sometimes, instead of an apparatus, it is sufficient to thicken the sole and lower the heel of the boot, so that the patient, in walking, must stretch his tendo Achillis.

If these measures are not sufficient, section of the tendo Achillis should be made, the anterior muscles of the leg being well massaged and stimulated electrically.[1] In the treatment of talipes arcuatus

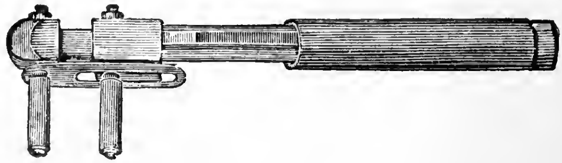

FIG. 389.—The H. O. Thomas' Wrench (Robert Jones).

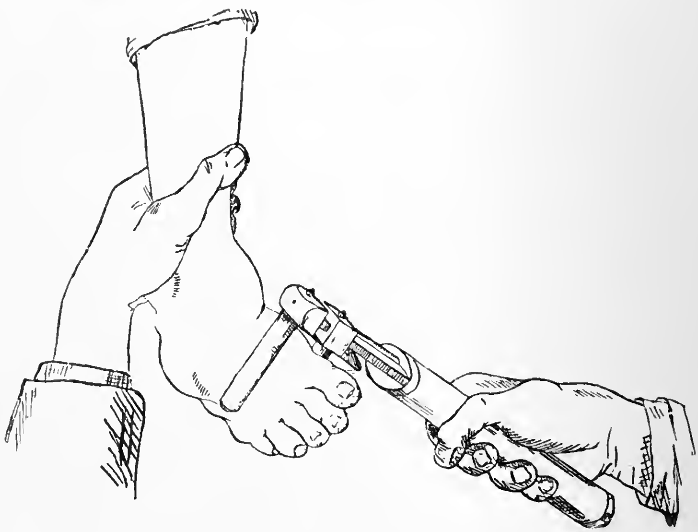

FIG. 390.—Reduction of the varus part of the deformity by the H. O. Thomas' Wrench (Robert Jones).

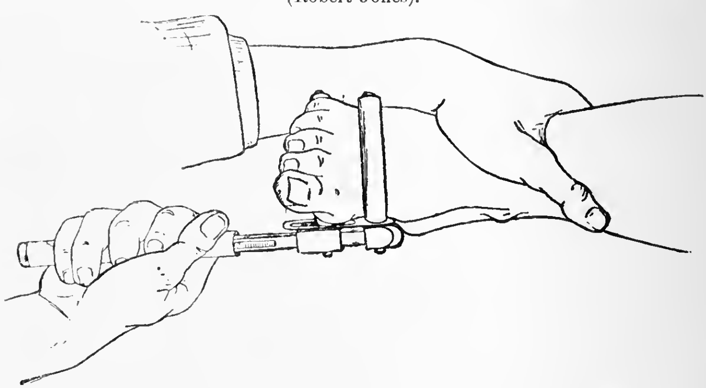

FIG. 391.—Reduction of the equinus portion of the deformity (Robert Jones).

[1] We draw attention here to the value of the "muscle beater" (*Surgery of Paralyses*, fig. 7, p. 48) and to vibratory massage worked by means of an electric motor. We think both forms superior to hand-massage.

and plantaris, section of the plantar fascia and extensor tendons is called for, and the reduction of deformity can be much accelerated by the use of the Thomas' wrench (Figs. 389, 390, 391, 392), or the author's modification of it (Fig. 393).

FIG. 392.—Overcoming the adduction of the foot at the medio-tarsal joint (Robert Jones).

When the tendo Achillis is so contracted that the heel is held permanently off the ground, and when the front part of the foot is dropped, it is advisable to conduct treatment in two stages: The

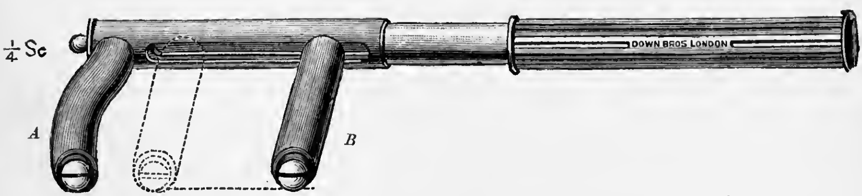

FIG. 393.—The author's modification of H. O. Thomas' Club-Foot Wrench. The apparatus is heavier and more powerful than the original. The upper arm is curved so as to fit the dorsum of the foot, and both arms A and B are oval on section (Down Bros. Catalogue).

shortened structures in the sole of the foot are attacked first, and, when the foot has assumed a normal shape, the tendo Achillis is divided or lengthened (Figs. 394, 395).[1] Generally, an interval of two or three weeks between the operations is necessary.

[1] It is not necessary always to make an open incision for Z-shaped lengthening of the tendo Achillis. The child is turned on its face, the tendon is made taut, a point is selected in the tendon about $1\frac{1}{2}$ inches above the heel, and the knife is inserted, with its edge turned outward, at the mid-point in the length of the tendon. The outer half is cut and the knife is withdrawn. It is then re-inserted at a distance of $\frac{1}{2}$ to $\frac{3}{4}$ inches

The immediate after-treatment consists of the employment of plaster of Paris, a tin-shoe, or a Scarpa's shoe according to the inclination of the surgeon. As soon as union of the tendon is assured, a walking instrument is ordered, with a calcaneus stop at the

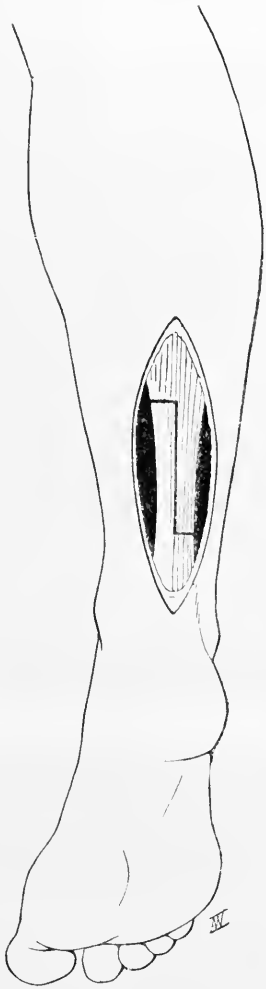

Fig. 394.

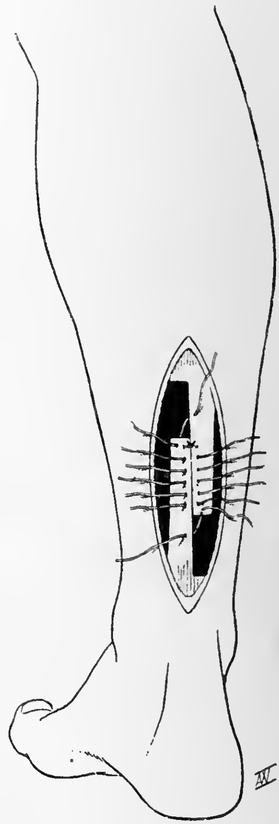

Fig. 395.

Two figures illustrating the Z-shaped method of elongating the tendo Achillis (Berger and Banzet).

ankle-joint, so as to obviate the possibility of undue stretching of the

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lower down, again at the mid-point in the length of the tendon, but with its edge turned inwards, and the inner segment is cut. By a forcible movement of dorsiflexion of the foot the tendon is split longitudinally between the two incisions, and is thus lengthened in a Z-shaped manner.

new band of union formed in the tendon. If this precaution is not taken, a very troublesome form of talipes calcaneus ensues. We have elsewhere adverted to this possibility, and I have described in Vol. I. p. 257 my method of dealing with this complication, by replacing the membranous remains of the tendo Achillis with an

FIG. 396.

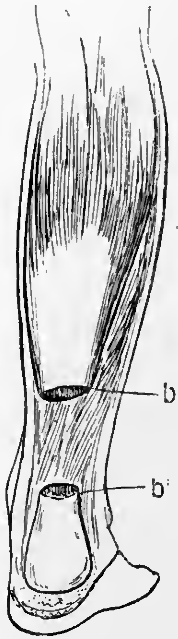

FIG. 397.

FIG. 398.

Three figures illustrating the author's method of restoring the tendo Achillis by the Insertion of Mercurialised Silk, in cases where the band of union has stretched after tenotomy for talipes equinus, and talipes calcaneus has followed.

FIG. 396.—*a*, Thin membrane, uniting retracted ends of tendo Achillis.
FIG. 397.—The thin membrane has been excised ; bb^1, refreshed ends of tendo Achillis.
FIG. 398.—Six strands of Mercurialised Silk uniting ends of tendo Achillis.

artificial silk tendon. In three cases I proceeded on the following lines (cf. Figs. 396, 397, 398):—

A longitudinal incision was made over the tendon, and all the membranous material was excised. The foot being held midway between flexion and extension, a long piece of silk was threaded six times through the freshened tendon-ends and the wound closed. The foot was placed in plaster, and three months after the operation it was found that the gap was bridged by strong and firm tendinous material, sufficient to permit the child to raise the body weight on the affected foot. If corns and false bursæ have formed and inflammation exists around them, time must be given to treating them before operative measures are proceeded with.

In those cases where the head of the astragalus is very prominent on the dorsum of the foot, and if it is not possible to replace the whole of the articular surface of the bone into the ankle-joint, a wrench may be freely used. Sometimes this fails, and then excision, either of part or of the whole of the astragalus, is called for, with shortening of the tendons, insertion of artificial ligaments, and exsection of lozenge-shaped portions of skin and subcutaneous tissues from the front of the joint.

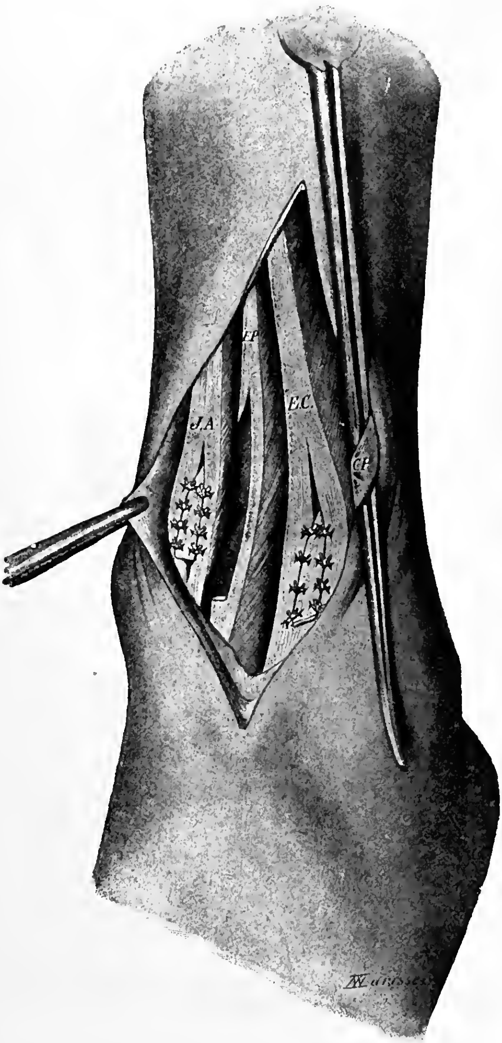

Fig. 399.—Transplantation of a slip from the Extensor Proprius Pollicis (E.P.) into the tendon of the Tibialis Anticus (J.A.); also of a slip from the Peroneus Brevis (C.P.) into the Extensor Communis Digitorum (E.C.) (Berger and Banzet).

Tendon - transplantation alone does not yield satisfactory results in this partial form of paralysis of the ankle. Various devices have been carried out, the most usual being splitting of the tendo Achillis into three bands, and transferring the two lateral bands to the front of the foot, and dividing the middle band. It is evident, however, that the bands transferred to the front cannot act independently, and therefore they merely become anterior ligaments of the ankle, and limit the action of the joint. We advocated this method, when we wrote on the subject in the *Surgery of Paralyses*; we have nevertheless abandoned it since. If the tibialis anticus and extensor communis digitorum are alone affected, the extensor proprius pollicis and the peroneus brevis tendons may be transferred respectively (Fig. 399). If the extensor communis alone is paralysed, slips from the extensor proprius pollicis and the tibialis anticus may be used (Fig. 400).

FIG. 400.—Transplantation of a slip of the Extensor Proprius Pollicis, $E.P._1$, into the tendon of the Extensor Communis Digitorum, E.C., one-half of the tendon of the extensor proprius pollicis, $E.P._2$, being left intact. It is also possible to deal in the same manner with the tendon of the Tibialis Anticus, J.A., which will assist in overcoming the equinus (Berger and Banzet).

Nerve-anastomosis has not been sufficiently tried for this affection for us to speak dogmatically on the subject. If we are dealing with pure equinus, if the foot is not flail-like, and the musculo-cutaneous nerve is quite healthy, the feasibility of grafting the distal end of the anterior tibial nerve into the musculo-cutaneous, or reinforcing the anterior tibial nerve by a slip from the musculo-cutaneous, may be considered. The former method is preferable because so little damage is done to the healthy nerve. In any case the dorsiflexor tendons are to be shortened and the anterior ligaments strengthened.

In complete paralysis of the ankle, where the foot hangs in equinus, the choice must lie between the use of a heavy and expensive instrument and the operation of arthrodesis, combined with shortening of the stretched tendons, implantation of artificial ligaments, and excision of a sufficiency of soft tissues on the front of the ankle. There can be little or no hesitation in telling out-patients, who are often unable to procure complicated apparatus, that operative measures are preferable. Arthrodesis of the medio-tarsal and calcaneo-astragaloid joints will be required as well in most cases.

2. **Paralytic Talipes Calcaneus.**—The feature of this deformity s excessive depression of the heel, with or without elevation of the toes. In the early stages, when the toes are elevated, the sole of the foot is not unduly concave; but, after a time, owing to the contraction of the soft parts, the concavity of the arch is greatly increased, and pes cavus appears. In long-standing cases of calcaneus, a prominence is frequently seen on the posterior aspect of the leg just above the heel. It is formed by the lower ends of the tibia and fibula, which become conspicuous, as the astragalus and foot are drawn forwards; the os calcis, or the astragalus and os calcis gradually drop, as it were at the ankle-joint, until the latter is nearly vertical. The heel is abnormally lengthened and ball-like, this appearance being accentuated by the large pad of fat and thickened skin, which forms over the posterior surface of the os calcis, which, in the deformed position, is now the inferior.

Treatment.—This is one of the most difficult forms of paralysis to treat mechanically when it is once established, and it is quite unsuitable for tenotomy, because section of the dorsiflexors does not in any way overcome the characteristic deformity, namely the drooping of the heel and the globular-like projection of the os calcis downwards and backwards. The mal-position can generally be avoided in anterior poliomyelitis by early mechanical treatment, so devised as to enable the patient to tread equally upon the anterior part of the foot and upon the heel.

In slight cases of calcaneus, an artificial tendo Achillis can be fitted to the boot, being fixed above to a metal band embracing the calf.

Operative Measures for Talipes Calcaneus.—As a preliminary it is essential to rectify the secondary deformity in the sole of the foot. This is effected by section of the contracted fascia, muscles and tendons, and then we may consider the treatment of the primary deformity. The methods advocated are: (1) Those designed to shorten the tendo Achillis; (2) Tendon-transplantation; (3) Various forms of arthrodesis and operations on the bones; (4) Nerve-transference.

(1) **Shortening of the Tendo Achillis.**—It is now agreed that all the methods, whether Willett's, Gibney's, or the Z-shaped procedure, are unsuccessful. We recognise that in calcaneus we have to deal, not only with elongated muscles, but also with relaxed ligaments and subluxated bones. It is therefore irrational to expect that the shortening of one tendon, which is a weakened, and often a membranous structure, will control a deformity which is so complex.

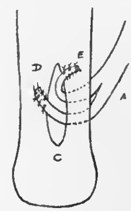

Fig. 401.—Diagrammatic representation of Nicoladoni's pioneer operation of inserting the Peroneus Longus into the Tendo Achillis. The divided end of the Peroneus Longus is drawn through the Tendo-Achillis at C, and sewn to its posterior surface at D and E.

(2) **Tendon-transplantation**, in talipes calcaneus, has not fulfilled the expectations formed of it. The proceeding, formerly advocated, was the original one of Nicoladoni, *i.e.* the insertion of the proximal end of the severed peroneus longus into the tendo Achillis (Fig. 401). It is true that some cases improved for a time, but, after three or four years, relapse occurred, and the deformity reappeared. Although at first the heel was held in fair position, yet, only in exceptional cases,[1] did it remain so.[2]

When the paralysis about the ankle is partial, and particularly in children, prolonged fixation of the foot in the attitude of equinus with a malleable iron splint has occasionally resulted in great improvement, and some apparently hopeless cases have been cured, provided that physical therapeutic measures were faithfully carried out on the calf-muscles. It is evident that in such instances they had been perpetually on the stretch, and had not been given a chance to recover, until the foot has been placed in equinus.

Sometimes, the immediate reduction of the deformity may be attempted. The contracted tissues in the sole are divided, and by

[1] See Cases 22 and 24, *Surgery of Paralyses*, pp. 130 and 132.

[2] Hunkin, *Amer. Jour. Orth. Surg.*, Nov. 1908, p. 203, has used the biceps cruris twice, bringing it into connection with the os calcis, presumably by long strands of silk-fibres. He was stimulated to do so on hearing of Soutter's ingenious use of the semi-membranosus with the object of raising the heel.

vigorous manipulation and wrenching, the heel may be pushed upwards and backwards, so that the foot is slightly plantar flexed. The tendo Achillis is shortened, and silk is put in to replace the posterior ligament. Care should be taken not to depress the front part of the sole only, as this will merely increase the talipes plantaris. Transplantation of the healthy flexor longus digitorum, of the peroneus longus, of the tibialis posticus, or any two of them, into the tendo Achillis or into the os calcis will give additional firmness to the part.

(3) **Arthrodesis.**—A posterior incision is made, or a flap is turned up, a portion of the tendo Achillis and soft tissues are excised, the joint is opened, and an arthrodesis done.

Whitman's Operation for Talipes Calcaneus.—This consists of astragalectomy, arthrodesis, tendon-transplantation, and backward displacement of the foot.[1] Whitman describes the operation as follows :—

"A long curved external incision is made, passing from a point behind and above the external malleolus, below its extremity, and terminating at the outer aspect of the head of the astragalus. The peronei tendons are divided as far forward as possible, and they are then completely separated from their sheaths and drawn to one side. The joint is then opened, and the foot displaced inwards. This forces the astragalus out from between the malleoli, and it is easily enucleated when its attachments to the neighbouring bones have been divided. A thin section of bone is then cut from the outer surface of the os calcis and cuboid. On the inner side the sustentaculum tali is cut away, and the calcaneo-navicular ligament is partially separated from its attachments. The cartilage is then removed from the two malleoli, and, if necessary, they are reshaped to permit accurate adjustment.[2] The foot is then displaced backwards as far as possible, so that the external malleolus may cover the calcaneo-cuboid junction, whilst the internal is forced into the depression behind the navicular. Finally, the peronei tendons, being the muscles which are active, are attached to the insertion of the tendo Achillis and to the os calcis by strong silk sutures. The wound is closed without drainage, and the foot is then fixed by a plaster bandage in an attitude of equinus. The object of the removal of the astragalus is to assure stability and to prevent lateral deformity by placing the leg bones directly upon the foot (cf. Vol. I. p. 348, Figs. 261, 262, 263). The

[1] *Amer. Jour. of Med. Sci.*, Nov. 1901 ; and Whitman, *Orthopedic Surgery*, 3rd ed. p. 828 ; *Amer. Jour. Orth. Surg.* vol. viii., 1910, p. 137.

[2] Instead of reshaping the malleoli, Goldthwait (*Amer. Jour. of Orth. Surg.*, Jan. 1908, p. 271) has devised a useful modification of arthrodesis (see also p. 649). Oblique division of the fibula above the malleolus ensures that the denuded articular surfaces of the astragalus are firmly held within the mortise of the ankle-joint.

object of the backward displacement of the foot is to direct the weight upon its centre, and thus to remove the adverse leverage that induces dorsiflexion. The tendon-transplantation is an additional safeguard against deformity, and is of some service in restoring function. As soon as possible the patient uses the foot in standing and walking. Ultimately, apparatus may be dispensed with, but the Judson brace should be used for a year or more, when it may be replaced by a shoe arranged to hold the foot in slight equinus."

Whitman has performed this operation in over fifty cases, and it is regarded by him as the "treatment of choice" in this type of deformity.

Robert Jones[1] describes his procedure thus:

"It is divided into two stages, four weeks intervening. In the first stage the plantar fascia is severed, and the sole of the foot is unfolded forcibly with the hand or the wrench. An incision is then made down to the bone about three inches in length on the inner side of the foot, the centre of the incision being opposite the most concave part of the sole. With a periosteal elevator separate the soft structures from the tarsus above and below from the inner to the outer side. Then just behind the medio-tarsal joint a V-shaped section of bone, with its base upwards, is removed (see Figs. 264, 267, Vol. I.). If there is valgoid deformity, the section should be wider on the inner than on the outer side. The wound is sutured, and the cavus portion of the deformity is obliterated by dorsiflexing the foot, which is now bandaged to the tibia, the calcaneus deformity being apparently much increased. At the second stage of the operation a longitudinal incision is made at the back of the heel, the centre being opposite the ankle-joint. The joint is opened, and a wedge is taken from the astragalus with its base backwards, and of sufficient size to permit the foot to be brought at right angles with the leg. The cartilage of the tibia and fibula is taken away. The foot is then fixed at right angles, and held so, until union is complete. This operation should not be performed in children below the age of eight, and is suitable for those cases where the paralysis of the calf muscles is complete.

"When some power remains in the calf muscles, the operation is modified. The first stage is carried out as before. In the second stage, the back part of the capsule of the ankle-joint is shortened, and so too is the tendo Achillis. An area of skin is removed from the back of the joint; and then, after three weeks, massage of the gastrocnemius and other muscles is carried out. In this case it is not advisable to remove bone. For some weeks after walking has commenced, the foot should be protected against strain."

A criticism which the writer ventures to think applicable to this operation is that it takes no note of the relaxation of the ligaments of the calcaneo-astragaloid joint, and it would be interesting to observe if any

[1] *Amer. Jour. of Orth. Surg.* vol. v., April 1908, p. 371.

dropping of the heel takes place subsequently in the completely paralysed cases. The operation is, however, ingeniously planned to meet the abnormal static conditions in paralytic talipes calcaneus.

(4) Nerve-transference (Vol. II. pp. 663-4) has been carried out by the author for talipes calcaneus, and has been partially successful.

Fig. 402.—"Surgical" boot for the correction of talipes varus, with a thickened sole on the outer side (Tubby and Jones, *Surgery of Paralyses*).

It will be seen, then, that the treatment of this deformity in all its stages presents considerable difficulties, nevertheless, the choice of procedures is wide and is sufficient to meet requirements.

3. **Paralytic Talipes Varus.**—It is rare to find the paralytic form so pronounced as the congenital. In a mild case, however, there is difficulty in everting the foot, mainly owing to the shortening of the tibialis posticus, and the internal lateral ligament of the ankle. In those patients who have had a transient palsy of the peronei, it is often noted that, in walking, the foot assumes a flapper-like action, and the toes are slightly inturned.

Treatment.—The treatment is mechanical, or operative by tenotomy and tendon-grafting, or it may involve a combination of measures. In the practically recovered cases, all that is needed, in addition to massage, is a small rim of leather or iron on the outside of the boot (see Fig. 402). In the more advanced cases, wrenching and an inside iron support, with a rim on the outside of the boot, are required (Fig. 403). So far as operation is concerned, some surgeons prefer to divide the tibialis anticus and posticus, but many will now perform tendon-transplantation. If the deformity has lasted a long time, and changes in the bone have resulted, a combination of tarsectomy on the outer side and tendon-transplantation will probably be indicated. In cases of medium severity the tibialis anticus and posticus are divided; the tibialis anticus is transferred and fixed to the cuboid bone or into the peroneus brevis just above its insertion; and the tibialis posticus tendon is brought behind the ankle and fixed to the peroneus longus; or, both the

Fig. 403.—A right boot for the Treatment of Talipes Varus, with inside upright to the calf and T-strap (Tubby and Jones, *Surgery of Paralyses*).

anticus and posticus tendons may be elongated with silk and fixed to the cuboid or base of the fifth metatarsal bone. When the joints are relaxed, particularly the ankle, arthrodesis is performed, and a wedge is removed from the upper surface of the astragalus, the base being outwards. Before closing the wound, an area of soft tissues should be taken from the outer side of the foot so as to assist in maintaining the correction.

In all stages of the affection, the foot is held everted in a splint during the night, in order to relax the peronei, and these muscles should be daily massaged vigorously. In walking and sitting, the inside of the foot ought to be directed to the ground, and eversion exercises sedulously practised. It must not be forgotten that whenever tendon-transplantation is done, not only should nutrition of the muscle of the transplanted tendon be vigorously stimulated by massage and electricity, but also considerable pains must be taken to protect and nurse the transplanted muscle, to re-educate it in the performance of its new functions.

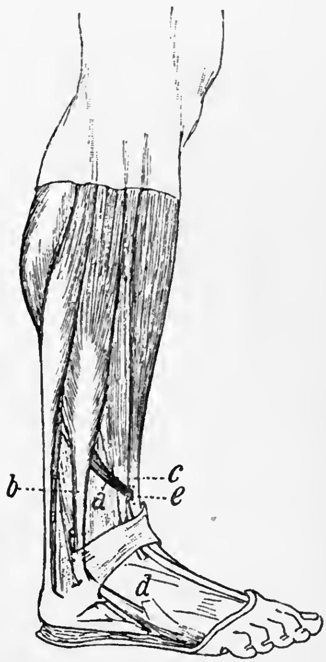

FIG. 404.—Tendon-Transplantation for the relief of Paralytic Talipes Valgus. The peroneus brevis, *a*, is divided and inserted into the tibialis anticus *c* at *e*. At *d* is seen the distal end of the peroneus brevis, and *b* marks the peroneus longus (Tubby and Jones).

Tendon-transplantation for paralytic varus and valgus has so far yielded the best results in the foot.

4. **Paralytic Talipes Valgus** is due to paralysis of the tibiales, and is commonly associated with paresis of the calf muscles, and sometimes of the flexors of the ankle. The patient walks on the inner side of the foot.

Treatment.—In slight cases, the boot is raised on the inner side, and the ankle is bandaged to an iron fixed to the outer side of the boot. Most cases, however, are better treated by transplanting the peroneus brevis into the tibialis anticus (Fig. 404) either above the ankle-joint, or preferably by dividing the peroneus brevis just above its insertion and fixing it to the inner part of the foot. In addition, the outer three tendons of the extensor communis digitorum may be divided and fixed to the periosteum of the inner side of the foot (Fig. 405). In some instances it is better to insert the peroneus brevis into the tibialis posticus by passing it beneath the tendo Achillis. A slip from the inner side of the tendo Achillis may be used to strengthen the tibial muscles, and increase the inversion of the foot. This is a good example of the principle that in tendon-transplantation synergic muscles should as far as possible be used, both the calf muscles and the invertors being supplied by the internal popliteal nerve.[1]

FIG. 405.—Transference of the outer tendons of the Extensor Communis Digitorum and the tendon of the Peroneus Tertius into the inner border of the foot for Paralytic Talipes Valgus. The insertion, *a*, of the transferred tendons is shown rather too far forward on the inner side of the foot (Tubby and Jones).

Many cases of talipes valgus are better treated by a combination of tendon-transplantation and arthrodesis. Strain should not be thrown upon any transplanted tendons for some weeks or even months, and when the patient begins to walk they should be protected from stretching. Nerve-anastomosis does not appear to be a hopeful procedure in either paralytic varus or valgus.

Complete paralysis of the muscles around the ankle-joint invariably calls for arthrodesis, in preference to the use of complicated mechanical apparatus.

Combined Forms of Paralytic Talipes.—The combined forms of paralytic talipes met with are (1) Talipes Equino-Varus, or the extended and inverted foot; (2) Talipes Equino-Valgus, or the extended and everted foot; (3) Talipes Calcaneo-Varus, the flexed and inverted foot; (4) Talipes Calcaneo-Valgus, the flexed and everted foot.

In all these forms, the paralysis may be either partial or complete, and the procedure differs according to the degree of paralysis. However, it may be said that a flail-like condition of the joints precludes either tenotomy or transplantation, and the choice must then be made between appliances and arthrodesis.

[1] In dealing with the preceding simple forms, and also with the combined forms, the Table in Vol. II. p. 629 giving the relative values in figures of the actions of the muscles and the various movements of the foot should be carefully consulted.

(1) **Paralytic Talipes Equino-Varus.**—When the weakness of the dorsiflexors and of the evertors is slight, and the foot is not much displaced, tenotomy of the tibialis anticus and posticus with section of the plantar fascia, and subsequently of the tendo Achillis, and careful treatment on the lines laid down for the after-care of the deformity, give excellent results.

This form of paralytic club-foot affords considerable scope for the ingenuity of the surgeon. The author has followed the plan of splitting the tendo Achillis throughout its entire length, carrying the division well up into the gastrocnemius, so making two muscles. The outer half of the tendo Achillis is then inserted into the peroneal tendons, thus replacing their paralysed bellies by the healthy outer half of the gastrocnemius.[1] The splitting of the gastrocnemius and soleus must not be carried too high; otherwise, the nervous and arterial supply of the new muscle will be interfered with. The remaining inner portion of the tendo Achillis is divided so as to overcome the equinus.

In severe cases of equino-varus it is useless to expect transplanted muscles to maintain the stability of the foot in standing, and to carry out at the same time complicated movements. Therefore arthrodesis at the ankle, sometimes combined with removal of a wedge from the outer part of the tarsus, is called for as an additional procedure. The stretched soft tissues on the outer side of the foot may be tightened up by the removal of an oval-shaped area, at the same time that the tarsectomy is done.

(2) **Talipes Equino-Valgus** is treated, either by tenotomy and mechanical appliances, or an attempt is made to restore the power of the invertors by splitting the tendo Achillis vertically, carrying the incision upwards partly through the gastrocnemius and soleus, and, using the inner slip of muscle and tendon so made, to re-inforce or to replace the lost invertors. The slip should be made as long as possible, and carried forwards, being inserted either directly into the inner aspect of the scaphoid bone or the tendon may be prolonged by means of silk strands. The remaining outer half of the tendo Achillis is divided (Figs. 406, 407, 408).

We may also attack this condition on other lines, by carrying out the operative procedure described above in paralytic valgus, and in addition dividing the tendo Achillis.[2]

[1] See Case 57, p. 151, *Surgery of Paralyses*, where four and a half years after this operation the patient was found to walk comfortably without any instrumental assistance, and the everting power of the foot had been regained.

[2] See Cases 33, 34, *Surgery of Paralyses*, pp. 139-146.

(3) **Paralytic Talipes Calcaneo-Valgus.**—The conditions at the ankle and in the foot often preclude the possibility of any successful result either from tenotomy, tenodesis (exsection of tendons) or tendon-transplantation. The part is so frequently flail-like, and there is so much relaxation of tendons, muscles, and ligaments, that nothing short of fixation of the joints avails. In fact, talipes

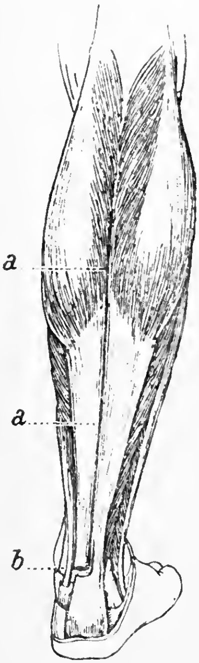

FIG. 406.

FIG. 407.

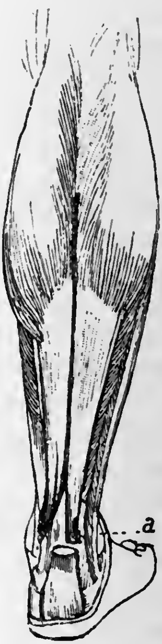

FIG. 408.

FIG. 406.—Operation for the relief of Paralytic Talipes Equino-Valgus. Splitting off at *a a* of the inner part of the gastrocnemius and tendo Achillis, and section at *b* of the inner half of the latter (Tubby and Jones).

FIG. 407.—The second stage of the operation. The inner half of the gastrocnemius and tendo Achillis. *a*, is brought forward and united either to the tibialis posticus *b*, or to the periosteum of the scaphoid (Tubby and Jones).

FIG. 408.—Final stage of the operation of relief of Paralytic Talipes Equino-Valgus. The outer half of the tendo Achillis is divided at *a* to relieve the equinus (Tubby and Jones).

calcaneus, if left to itself, frequently becomes complicated with valgus. In describing the operations on the foot for calcaneus we alluded to this point, and described certain modifications designed to overcome the valgus. The ankle, sub-astragaloid, and medio-tarsal joints, may be fixed by arthrodesis; or modifications of Royal Whitman's or Robert Jones' operation for talipes calcaneus be carried out.

(4) **Paralytic Talipes Calcaneo-Varus** is due to loss of power in the calf and evertor muscles, and is treated on the same lines as we have described for varus and calcaneus, with the like careful attention to indications, and similar reservations, according to the extent of paralysis. It is needless to re-iterate the proceedings in full, and the surgeon will be guided by a careful appreciation of the extent of the weakness, the amount of power which remains, and the desirability of striving for a fixed ankle and sub-astragaloid joint in a foot where some of the tarsal movements are reconstituted by tendon transference.

FIG. 409.—Paralytic Talipes Equino-Valgus, before treatment (Tubby and Jones).

We have thus dealt at considerable length with the treatment of the various forms of paralytic talipes, and we have attempted to give indications of the various procedures. It now remains to speak again of nerve-transplantation in this connection. The cases in which it has been tried are few, and partial success has been obtained where the bundles of fibres going to individual muscles have been transplanted. When a large nerve-trunk, such as the internal popliteal, has been inserted into the external popliteal, or *vice versa*, the results have not been satisfactory, although we believe that this has been due to defects in the preliminary treatment, and in the technique. Further experience is required. We doubt if nerve-anatomosis alone can ever be the only treatment for paralytic talipes. The foot, though possessed of intrinsic movements, supports the weight of the body, and at present it is not clear that the muscles can be so regenerated by nerve-transference as to carry out the two functions completely.

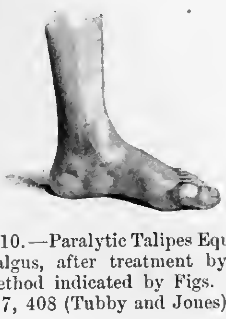

FIG. 410.—Paralytic Talipes Equino-Valgus, after treatment by the method indicated by Figs. 406, 407, 408 (Tubby and Jones).

A consideration of the preceding pages will convince the reader that, with the exception of arthrodesis or very flail-like joints, no one form of operative treatment is available for the majority of cases of paralytic talipes. In almost every instance a combination of methods is essential, and success will depend upon the care and judgment with which they are carried out.

B. Paralysis of the Muscles controlling the Knee.

The forms met with are :—

1. Paralysis of the quadriceps muscle, without contraction.

2. Paralysis of the same muscle, with contraction of the hamstrings.

In these types the sartorius frequently escapes. It is essential to verify the existence of good power in this muscle, as it becomes of great use, by muscle-transference, as a partial substitute for the extensor. Happily, too, the hamstrings frequently escape; and it is a very rare occurrence to find them to be the only muscles affected.

3. Paralysis of all the muscles of the knee, without contraction.

4. Paralysis of all the muscles of the knee, with contraction of the flexors.

5. Paralytic genu valgum.

When paralysis of the limb is complete, flexion deformity at the knee, or external rotation of the tibia, genu valgum, or genu recurvatum may be present.

Before the knee can be effectually treated, it is necessary to place the ankle under such control that the sole of the foot is flat upon the ground, for any lateral deviation there entirely prevents a successful mechanical result at the knee-joint. When, however, there is much shortening of the limb with complete paresis of the flexors of the ankle, it is advisable to make up the deficiency by a boot so constructed as to keep the toes near the ground.

When the foot is in good position, we can deal with the knee; and, if the ilio-psoas muscle still retains its power, we may assure the patient, however helpless he may be, that he will be able to walk subsequently. The principles of treatment of paralysis about the knee are :—

1. To ascertain the condition of the muscles, as to their partial retention of power. This is effected by noting the positions of the limb in the various movements which the patient retains, and by a careful electrical analysis of the muscles.

2. To rectify any deformity of the knee, such as lateral deviation or flexion.

3. To stimulate the muscles to renewed contractility, if any active tissue remains.

4. To utilise, by muscle-transference, the power left about the knee.

5. To supply an apparatus, simple and inexpensive, which will bear the body weight during locomotion. For this purpose no apparatus is so suitable as the Thomas' calliper splint (see Figs. 161 and 186).

Subluxation of the Patella.—When the extensor is partially paralysed, the ligamentum patellæ becomes so lax that subluxation of the knee-cap outwards or inwards takes place from time to time, and the patient is temporarily unable to walk. With each successive displacement of the bone, the ligament becomes more lax and the condition worse. As a rule the displacement is outwards.

The author has adopted a simple operative procedure for this condition, when the occupation of the patient is such as to render the wearing of an apparatus impossible, or when the patient is unwilling to be bothered with such a contrivance. In 7 cases he has made a transverse incision one and a half inches above the patella, and has then pleated the extensor tendon on itself, the depth of the fold varying according to the relaxation of the tissues. It is generally from half an inch to one inch. Four or five sutures are then passed through the fold (see Figs. 268, 269, p. 517), the wound is closed, and the limb placed in plaster of Paris for four weeks. In no case has any displacement occurred subsequently, and the patient has completely regained his confidence when walking.

Other procedures have been advocated for this condition. If the patella slips outwards, the sartorius is divided and fixed to the inner margin of the patella. This we have done twice (Fig. 412). On account of the oblique action of the sartorius we have found it better, however, not to use this muscle, but to employ the gracilis. Other surgeons have boldly displaced the tubercle of the tibia, with the ligamentum patellæ attached, inward or outward as the case may require. This procedure is not necessary, as the simple methods, used by the author, suffice.

We may now revert to the conditions of more extensive paralysis at the knee.

1. **Paralysis of the Quadriceps, without Contraction.**—If the sartorius or the hamstring muscles retain contractile power, the right

course of treatment to suggest to the patient is muscle-transference. After watching these cases for several years, it has been found that the best and most satisfactory results have been obtained by Goldthwait's procedure, for paralysis of the extensor muscles of the knee. The sartorius, as we know, frequently escapes. If left intact, this muscle aggravates the condition by increasing the flexion of an already bent knee; if it is divided opposite the upper part of the patella, and the central end brought forward, and inserted into the periosteal covering of that bone; and if the muscle is thoroughly massaged afterwards, it is

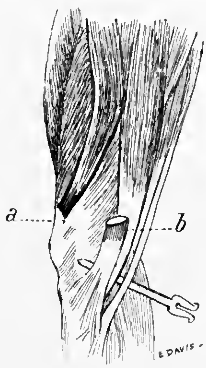

FIG. 411.

FIG. 412.

FIG. 411.—Lateral view of the inner side of the knee, to show Transference of the Sartorius to the upper edge of the patella at *a* for Paralysis of the Extensor Cruris Muscle. The distal part of the sartorius is seen at *b*. If the sartorius is fixed to the inner side of the patella, dislocation of the patella outwards is prevented (Tubby and Jones).

FIG. 412.—Transference, completed, of the proximal part of the sartorius into the patella, to re-inforce the extensor quadriceps. At *a* is the distal part of the sartorius. At *b* is its peripheral part (Tubby and Jones).

found, in properly selected cases, that the patient is able to stand with the knee firmly braced, and in about 50 per cent of the cases (mostly in children and young adults) the power of complete voluntary extension is gained. The latter event is more likely to occur if some of the hamstring muscles are transplanted as well. He has, on occasion, used the biceps in addition to the sartorius; and when the biceps appeared to be much wasted, a part of the inner hamstrings has been used. In the Hunterian Oration [1] some

[1] A. H. Tubby, "Hunterian Oration of the Hunterian Society," March 31, 1906, *Brit. Med. Jour.* vol. i. 1906. Also *Surgery of Paralyses*, pp. 155-158.

successful cases are given in detail, and Goldthwait's results are also quoted. The tensor vaginæ fasciæ may also be used to extend the knee through the ilio-tibial band.

Hunkin[1] describes a very original procedure. In a girl, aged five years, the subject of severe poliomyelitis, which prevented "her ever getting from the sitting posture," the left rectus abdominis was made use of by him, so as to enable her to advance the leg. "An incision was made over the lower end of the rectus abdominis, the anterior wall of the muscle-sheath was slit up, the tendon was detached from the symphysis and ramus of the pubis, and a No. 3 double silk Lange suture was fastened into the flat tendon and lower part of the muscle. The silk suture was then passed in front of Poupart's ligament to the lower part of Scarpa's space, then through the sheath of the rectus femoris, and out just above the patella, subcutaneously over the patella to the tibial tubercle, and the usual sub-periosteal implantation. The precaution was taken, after lifting the muscle from its sheath, to strengthen the abdominal wall at this point by bringing together the split edges of the anterior wall of the sheath behind the muscle and attaching the sheath to the transversalis fascia behind. Arthrodesis was done at the ankle. Muscle-transferences were also made at the knee and ankle of the right leg. . . . The child is able to stand on and advance the left limb, and she can even take a few steps unsupported." Hunkin says that in "transplanting the sartorius, he has passed this muscle through the cavity of the knee, bringing it out above the patella, and has in two instances passed the silk from the tensor vaginæ fasciæ through the rectus femoris sheath in the same manner."

It is in paralysis of the extensors of the leg that Lange's method of elongating the transposed tendons of the inner and outer hamstrings finds its special use (Fig. 345). The object of the silk tendon is to secure an attachment to the tubercle of the tibia instead of to the upper margin of the patella, as in Goldthwait's procedure, and Lange says that in only two of his cases were the results unsatisfactory. Several of the artificial tendons were eight inches long, and the functional results were excellent. Patients in whom the semitendinosus and biceps were made to replace the quadriceps femoris often regained almost normal power of extension. From 1901 to 1906 Lange operated upon 200 cases. Lange advises that all the hamstrings be transplanted to the front, except, when the gastrocnemius is paralysed. If one hamstring alone is used, it may fail to learn to contract independently of its group, and voluntary movement is impossible; or, it takes years to re-educate the muscles. It may be added that such is not the author's experience on this point. In

[1] *Amer. Jour. Orth. Surg.*, Nov. 1908, p. 204.

paralysis of the extensors, Lange depends solely upon the gastrocnemius to secure flexion at the knee, and if this muscle is paralysed the semimembranosus must be left; otherwise, genu recurvatum will result. Indeed, one of the most satisfactory methods of treatment for paralytic genu recurvatum (Fig. 413) is transplantation of either the

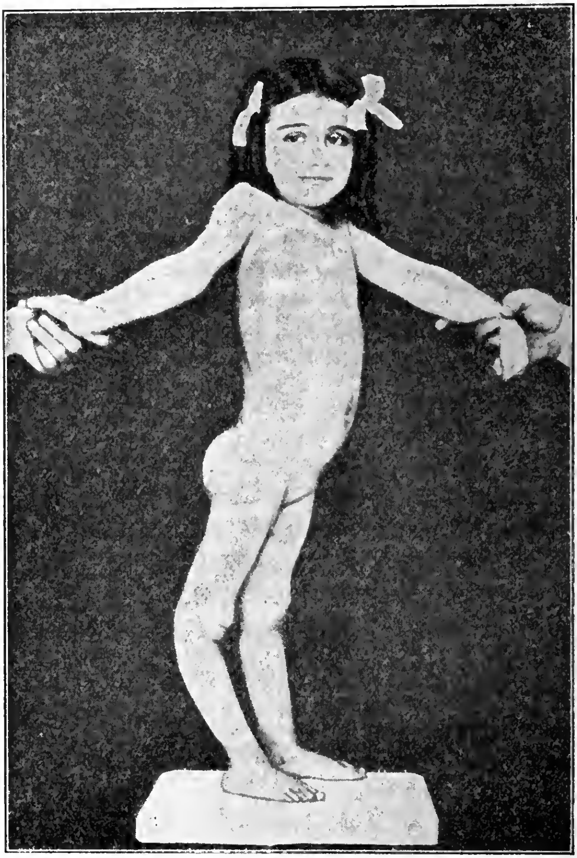

FIG. 413.—Anterior Poliomyelitis, causing Genu Recurvatum (Royal Whitman).

sartorius or some of the hamstrings.[1] Lange suggests that transference of the hamstrings is an improvement on even Nature herself; because whilst the normal quadriceps muscle extends the knee it flexes the

[1] Lorenz (*Centralblatt für Chirurgie*, 1905, No. 49), however, considers that tendon-transplantation has been overdone, especially in paralytic flexion of the knee. In these cases it is easy to produce hyper-extension of the knee by the operation (Binnie, *Manual Oper. Surg.* 4th ed. vol. ii. p. 495).

hip, but the transplanted hamstring muscles extend both the knee and hip. He criticises the use of biceps and sartorius simultaneously, because, although they can both be made into knee-extensors, they are naturally one a flexor and the other an extensor, and normally have antagonistic actions.[1]

In performing these transplantations of muscles, one great cause of failure is that strain has been thrown too early upon them, and patients have been allowed to walk within a few weeks. The knee should be kept straight for at least six months, and meanwhile every care is taken to improve the nutrition, size, and power of the transposed muscles by massage, muscle - beating, and electricity. When movement is allowed at the joint, it should be limited at first to a few degrees, and then gradually increased. With these precautions the best results follow. The only exceptions are in the cases of stout adults with heavy legs. The leverage is too great to permit full extension of the leg, when the patient is sitting. Many, however, stand with the knee quite firm.

FIG. 414.—Paralysed left lower limb, with Genu Recurvatum (Bradford and Lovett).

If the patient declines operation, we must resort to the use of a calliper splint, or a walking apparatus, rigid at the knee; and, it sometimes happens that when the strain is taken off, the over-

[1] An excellent combination is transference of the sartorius and ilio-tibial band into the patella. In reply to Lange's criticism as to the extensor action of the sartorius, it may be pointed out that it is only that portion of the muscle, extending from opposite the upper border of the patella downward, which is a flexor, and that only, when the knee is bent a little. By dividing the sartorius opposite the upper border of the patella, and inserting its central end there, it naturally becomes an extensor of the leg.

stretched and apparently hopelessly paralysed quadriceps shows signs of recovery, and the knee is ultimately braced up.

The appearance of genu recurvatum in these cases is an interesting example of deformity originating on the paralysed side, and is

FIG. 415.—Infantile Paralysis of right leg, with Contraction of Knee (Bradford and Lovett).

FIG. 416.—Paralytic Genu Valgum (Bradford and Lovett).

due to the fact that when the leg is swung forwards by the action of the ilio-psoas muscle, the patient, in order to come down on the foot and secure a firm base of support, relaxes the flexors, and the knee bends backwards, owing to the weakness of the extensors.

2. **Paralysis of the Extensors, with Contraction.**—Here, we have at our disposal, for treatment, mechanical extension, tenotomy, muscle transplantation, arthrodesis, and osteotomy.

In order to overcome flexion by mechanical means, it is sufficient to place the limb in a Thomas' hip-splint and fix it by extension-straps, with pressure pads applied to the front of the thigh and leg. In more obstinate cases an anæsthetic may be given, and an attempt made to straighten the knee, with discretion. This treatment should be repeated every week until the flexion has disappeared, the limb during the intervals being kept well stretched on the splint. It is

FIG. 417.

FIG. 418.

Two photographs showing a typical attitude in walking, when the Extensor Cruris is partially paralysed. In Fig. 417 the child is seen to be standing, although mainly on the left leg, without assistance. In Fig. 418 the weakness of the right extensor cruris is evident, and the child steadies the knee with the hand, as the limb on the affected side is brought forward.

better, however, in most cases to divide the hamstrings; and an open incision should always be made for this purpose, care being taken to incise the skin along the tendons, and not across the popliteal space.

A slight degree of genu valgum (Fig. 416) can be successfully combated by making the inner iron of the calliper splint slightly bowed, and bandaging the limb to the outer bar.

When the knee has been straightened, and it is evident that power exists in the contracted flexor muscles, the advisability of muscle-transference is considered ; if, at the time when the open tenotomies are done, the flexion yields completely or nearly so, it is quite easy to extend the operation, and transfer some of the flexors to the upper border of the patella.

Many cases, however, present bony deformities and such obstructions in the joint, from backward dislocation and uneven growth of the condyles, that it is necessary to treat them either by arthrodesis or osteotomy, linear or wedge-shaped.

Arthrodesis at the Knee.—The loss of even passive extension and flexion at the knee will in most cases be keenly felt, and therefore arthrodesis at the knee is not often practised. Most patients prefer to wear supports, consisting of a mechanical arrangement opposite the knee-joint, which permits the part to be stiffened in standing and flexed in sitting. However, for a poor out-patient, and particularly in the case of a workman whose occupation involves standing, it may be a great boon to be independent of supports. Arthrodesis is particularly suitable also at the knee when we are dealing with an inverted limb and a flexed knee, with external rotation of the tibia. These patients cannot tolerate, without excoriation, any attempt at mechanical rectification, and arthrodesis is the best remedy. In an adult, the operation may be sufficiently extensive to justify the term wedge-shaped exsection. Arthrodesis should never be done to overcome the knock-knee so often associated with infantile paralysis. It is better to perform a femoral osteotomy to correct the lateral deviation.

Osteotomy.—Linear osteotomy at the lower end of the femur is called for when paralytic genu valgum fails to yield to splints, and sometimes it is useful at the upper part of the femur in contraction of the hip. If employed for genu valgum, it should be limited to those cases where there is merely lateral deviation and no flexion deformity. After the operation, a calliper splint is worn for some months.

Cuneiform Resection.—This operation is sometimes performed at the knee with the object of reducing the deformities arising from flexion and backward displacement. The same incision as that for arthrodesis suffices, and a V-shaped piece of bone should be removed from the femur.

3. **Paralysis of All the Muscles of the Knee, without Contraction, or Flail-Knee**, is a very serious disability; yet, provided the ilio-psoas is intact, we can generally assure the patient that, when the contractions at the hip have been overcome, we can provide mechanical means by which he will be able to walk in security.

The simplest method is the calliper splint from the boot to above the knee. The question of arthrodesis may come under discussion, and some patients may prefer it.

4. **Paralysis of all the Muscles of the Knee, with Contraction of the Flexors.**—The treatment of this condition is to reduce the contraction and then fix the joint, either by mechanical means or by arthrodesis. In those cases where both knees are affected, the methods are the same. Crutches help walking at first, but should be discarded for sticks as soon as possible.

Nerve Anastomosis for Extensor Paralysis.—Hans Spitzy has made experiments on animals, and has performed some operations on patients. He has attempted to regenerate the anterior crural by anastomosing the superficial branch of the obturator into it; but so far as we can gather, the results have not given satisfaction.[1]

C. Paralysis about the Hip

1. In some cases there is merely weakness of the extensors and abductors, which permits undue action of the flexors and adductors, and results in shortening of these muscles and contraction, if neglected. The deformity is overcome by tenotomy and mechanical means, the weak muscles are nurtured, passive and active exercises carried out, and the patient walks fairly well.

2. **Paralysis of all the muscles around the hip** may exist, with the exception of the psoas and iliacus, and perhaps the sartorius and tensor vaginæ femoris. This condition may be present with or without contraction on the flexor aspect. If present, contractions are dealt with, a walking apparatus is fitted (Vol. II. p. 623), and the patient is enabled to walk. Lange has substituted the vastus externus for the gluteus medius and minimus.[2] He detaches the upper attachment of the vastus externus from the trochanter major, weaves eight or ten silk threads into the vastus

[1] Lange, *Amer. Journ. Orth. Surg.* vol. viii. No. 1, Aug. 1910, p. 12, speaks very guardedly on the utility of neuroplasty in most cases of infantile paralysis.

[2] *Ibid.* p. 19.

externus, and sews them into the crista iliaca. He has been astonished at the extraordinary power of abduction thus obtained. Soutter has transferred a portion of the erector spinæ into the same muscles.[1]

3. **Complete Paralysis of the Muscles and a Flail-like Limb.**—If one limb only is affected, and, even if only the ilio-psoas is intact in the other limb, walking can still be secured by the use of appropriate apparatus fitted to both limbs.

4. **Paralytic Dislocation of the Hip.**—The most important point to ascertain is whether the ilio-psoas has or has not escaped. Even in monoplegia below the hip the patient can be enabled to walk; and in cases of paraplegia, so long as the ilio-psoas remains

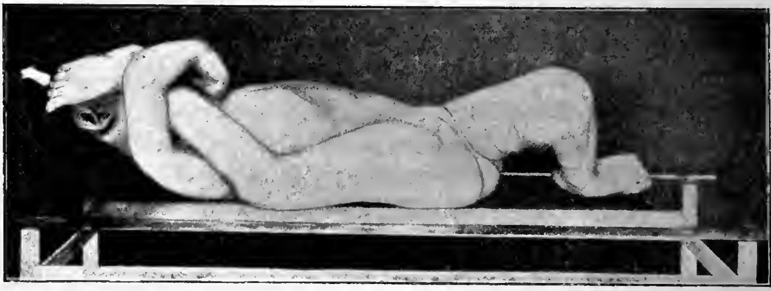

FIG. 419.—Anterior Poliomyelitis. The paralysis of the muscles at the hip allows subluxation of the hip (Royal Whitman).

intact on one side, we are able to achieve the desired result, since the patient is enabled to bring the other limb forwards by a swinging action of the pelvis. Nearly all patients with paralysis about the hip-joint have contraction on the flexor aspect, and this must first be removed. In slight cases, the contraction may be treated by recumbency in bed, with weight extension, or by a double Thomas' splint.

Tenotomy and fasciotomy—performed by the open method—of the muscular structures below the anterior superior spine and on the inner side of the thigh will expedite the reduction. When the patient begins to get about, a calliper splint or a simple appliance with a pelvic band is very useful.

Paralytic dislocation of the hip-joint may be either partial or complete. In partial dislocation the head of the bone appears to slip out and in (one form of Snapping-Hip). In complete dislocation

[1] *Loc. sup. cit.*

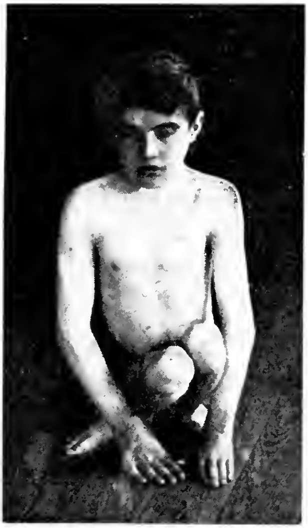

Fig. 420.

Fig. 421.

Fig. 422.

Fig. 423.

Fig. 420.—Paralytic Deformities of the Lower Extremities. Patient had not stood since birth (Tubby and Jones, *Surgery of Paralyses*).

Fig. 421.—Showing the method of progression of the patient in Fig. 420, who lifts the feet with the hands (Tubby and Jones).

Fig. 422.—The same case as in Figs. 420, 421. After Arthrodosis of one knee and of both ankles, and Osteotomy above the knees (Tubby and Jones).

Fig. 423.—The same patient some months later. He now walks with sticks (Tubby and Jones).

the head of the bone is frequently found on the dorsum ilii; it may assume other positions, which are determined by the contractions of various groups of muscles.

The primary cause of dislocation is weakness of some of the muscles and relaxation of the capsule of the joint. The position, which the head ultimately takes, is dependent upon the shortening of non-paralysed muscles. Perpetuation of the deformity is due to contracture and the effect of the body weight. After a time, marked lordosis is seen.

The condition is a very difficult one to treat, because, if complete reduction is effected, so soon as weight is borne upon the limb the head slips out. As a rule it is better to neutralise the body weight by mechanical means. A simple method is the Thomas' calliper splint, in which the tuberosity of the ischium, in standing, presses upon the inner thickened part of the ring. Whether resection of the head is a justifiable proceeding or not is a moot point; the writer believes it is not. He would nevertheless suggest the desirability of considering whether the head of the femur, after reduction, can be anchored by silk-worm gut to the acetabulum, in the same way that he has done in some cases of congenital dislocation. It may also be possible to re-inforce the joint by pleating or exsecting portions of the capsule, and performing muscle transplantation, *e.g.* putting a part of the erector spinæ into the gluteus medius. The association of coxa valga (Vol. I. p. 614) with paralytic deformities of the lower extremity should not be overlooked.

From what has been said it can be gathered that the treatment of cases of paralytic deformity is of the most hopeful character, and no one is justified in condemning a patient to the life of a cripple when such great improvements are possible: improvements which will assume a still more beneficial aspect, as greater advances are made in the science of orthopædic surgery. We have had under our notice and treatment cases in which a child has been brought to us shuffling upon his buttocks, with his legs twisted under him like a Chinese idol, and he had been condemned to a hopeless existence. We have seen such unfortunate beings, with the feet in any position, the knees tightly contracted, the hips flexed and almost immobile, and we have been able to unfold gradually all the contractions, so that many of them are now active and useful members of society (Figs. 420-423). Surely, it is time that the pessimistic tone of the literature dealing with the treatment of infantile paralysis be abandoned.

CHAPTER IV

SPASTIC PARALYSIS OF INFANCY AND CHILDHOOD

Varieties—Ætiology and Pathology—Symptoms—Prognosis—Treatment, General and Surgical, Mechanical and Operative—After-Treatment and Education.

Synonyms—Cerebral Paralysis of Childhood; Little's Disease; Spastische Gliederstarre.

Varieties—Spastic Paraplegia; Infantile Hemiplegia; Monoplegia; Cerebral Diplegia.

In orthopædic practice a large number of these cases are seen, and they constitute a group, second only in importance to anterior poliomyelitis. The affection, however, differs entirely from it. Spastic paralysis is characterised by motor weakness and incoordination, by stiffness and loss of control.

In 1853, the late Dr. Little drew attention to this group of nerve disorders. The incidence of the lesion and its effects are variable. When it is of cerebral origin, and is bilateral in its results on the limbs, it is known as "cerebral diplegia"; when it affects one-half of the body it is called "hemiplegia"; and if one limb only is involved—a rare event—it is a "monoplegia." If the nerve disorder is limited to the lower part of the body and is due to a lesion of the spinal cord, and not of the brain, the condition is one of "paraplegia," which must, however, be clearly distinguished from diplegia, where there exist bilateral cerebral lesions. The term "Little's disease" (Fig. 424) is applied only to bilateral (diplegic), and not to hemiplegic or monoplegic cases.

In accordance with this variable distribution there are certain clinical types of the affection. Thus, in cerebral diplegia it is found that whilst rigidity and paralysis are associated, the rigidity is the more striking feature. In the hemiplegic form paralysis preponderates, rigidity is secondary to it, and the arm is more affected than the leg. The reverse is the case with the diplegic varieties. A bilateral spastic hemiplegic form has been described, but there is no difference, however, between it and the severe forms of cerebral diplegia, in which there is much rigidity.

FIG. 424.—Spastic Paraplegia, Little's Disease (J. K. Young).

A rare variety is that known by the names of congenital chorea, bilateral athetosis, and choreic diplegia. The athetotic movements are frequently seen in the tongue, and in severe cases the muscles of the trunk and limbs are involved. Convulsions are not well marked, and the mental condition of the patient is good. We mention the varieties to show how complex the clinical picture may be.

Of 837 cases collected from various sources, 510 were hemiplegic, 30 monoplegic, 140 paraplegic, and 157 diplegic.[1]

Ætiology and Pathology.—Cerebral paralysis in children is either congenital or acquired. The late Dr. Little ascribed his cases

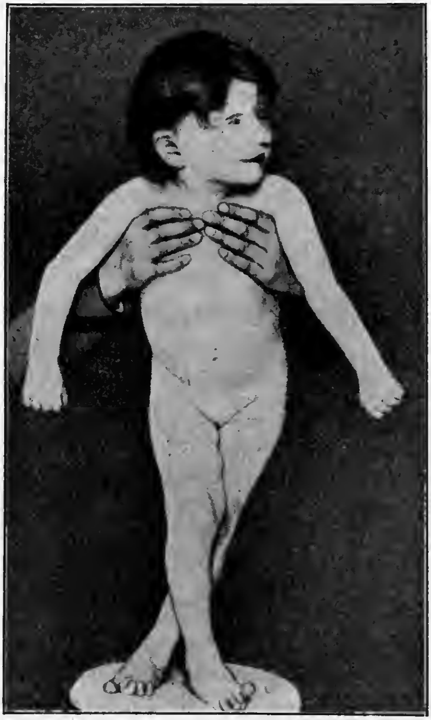

Fig. 425.—Congenital Cerebral Diplegia and Idiocy (Royal Whitman).

to premature and difficult birth, and to asphyxia neonatorum. If a large number of cases are studied, it will be found that in about two-thirds of them some condition of disease, either in the mother or child, can be traced. To render the ætiology clear we may classify the cases as follows :—

1. Paralysis of intra-uterine origin.
    (*a*) Large cerebral defects, such as porencephaly and absence of the grey matter.

[1] Tubby and Jones, *Surgery of Paralyses*, p. 199.

(*b*) Hæmorrhage and softening.
(*c*) Microcephaly.
(*d*) Syphilis.
(*e*) Specific fevers.
(*f*) Eclampsia and convulsions.
(*g*) Injury.
(*h*) Repeated pregnancies. There can be no doubt that cerebral paralysis more often affects the younger children of a large family than the older ones. Consanguinity of the parents has also been noticed.

2. Traumatism occurring during labour, *e.g.* injuries to the head produced by forceps and by prolonged labour, leading to laceration of the vessels of the brain. The hæmorrhage is very seldom intra-cerebral; it is either on the surface of the cortex or into the arachnoid cavity. It leads to meningo-encephalitis chronica, sclerosis, cysts, and porencephaly.
3. Paralysis acquired after birth.
(*a*) Meningeal hæmorrhage; embolism; thrombosis from syphilitic arteritis, and in association with marasmic conditions. As a result of them, vascular lesions, cysts, softening, atrophy, and sclerosis follow.
(*b*) Chronic meningitis.
(*c*) Hydrocephalus.
(*d*) Primary encephalitis (Strümpell).

We have remarked how often premature birth is associated with some cases, and this is more particularly seen in connection with the diplegic form. It is well known that the crossed pyramidal tract at the seventh month of fœtal life has reached the medulla only; and if an arrest of development of that tract occurs in a child, born prematurely at the seventh month, then general rigidity may follow. At the eighth month the tract is pushing its way down the spinal cord as far as the dorsal region; and if an arrest of its development occurs at that stage, then diplegic rigidity of the lower extremities may ensue. In premature children, non-medullation of the pyramidal tracts occurs. Whilst these observations will account for a certain proportion of cases, unfortunately the affection in question occurs also in children, not born prematurely. It is probable, nevertheless, that the same morbid process which causes the nerve affection induces premature birth.

We must therefore recognise that there is a wide divergence in the causes and the degrees of the affection; and from general rigidity of some or all of the limbs with entire loss of useful movement, to a slight contraction of the calf muscles, all grades are seen. In the less severe cases there is always a distinct and natural tendency to improvement, more especially when the lower extremities alone are affected; and, the contention of the author is that this natural tendency should be taken advantage of and aided by all possible means.

Symptoms. — The cardinal symptoms of the affection are, muscular rigidity, which becomes more marked if the limb is moved either passively or actively, and disappears under an anæsthetic; paresis; ill-directed and perverse movements; contractures; increase of the deep reflexes; inequality of growth of the limbs; and, sometimes, mental deficiency. The exaggeration of the reflexes, combined with impairment or inhibition of the higher centres, results in spastic rigidity of the limbs; and this induces distortion, which finally becomes fixed by changes in the tissues.

As the centres governing the nutrition of the parts escape to a great extent, the muscles waste very little, and the circulation is not markedly affected. In some instances, shortening or stunting of

FIG. 426.—Cerebral Hemiplegia (J. K. Young).

the limb is observable, but it is never comparable in degree to that seen in anterior poliomyelitis. In the severest cases of all, usually the cerebral diplegic, the rigidity is frequently of such a degree that the patient lies extended like a log. In other cases it is impossible for the patient to sit down, because he is unable to relax the extensors of the thighs and legs. In still others the movements of the hands and arms are good, or one arm alone may be affected, whilst the patient walks with difficulty on account of the spastic condition of the lower extremities. Lateral curvature of the spine is sometimes seen.

FIG. 427.—Congenital Cerebral Diplegia (J. K. Young).

The mode of walking is typical. The patient progresses on the toes, with the heels raised, the knees flexed and pressed together, the thighs rotated inward, and the body thrown forward. The flexors of the hips, the adductors of the thighs, the flexors of the knees and the plantar flexors of the ankles, are tightly contracted, and, later, become structurally shortened. As the adductor contracture increases, the legs are crossed, and the "scissor-walk" is produced.

The upper extremity, when spastic, is flexed at the elbow; the forearm is firmly pronated, the wrist fully flexed, the thumb adducted and contracted into the palm, and the fingers are flexed. The limb is often wasted, shorter than its fellow, and sometimes colder. The movements are clumsy, and athetosis may be present. It may be added that sensation is seldom interfered with.

Some of the cerebral diplegic cases are hopelessly idiotic; many others are feeble-minded. Mental impairment is more marked in the paraplegic and diplegic than in the hemiplegic form, because, in the latter, one half only of the brain is involved. Patients whose mental condition is sufficiently striking to be noticed, yet present no great departure from the normal, are found to fall under two types, the placid and the irritable. Both types are often associated with a good memory for abstract matters, such as figures and dates.

The placid type is a child of a happy disposition, not easily ruffled, frequently smiling, and not subject to gusts of temper; whereas the irritable type is an example of perpetual movement. The temper is intolerable; the child throws himself upon the ground in storms of passion, and the mother says that "he is so mischievous that nothing is safe from him." Some of these children show tendencies to cruelty and incendiarism. It is, however, worthy of remark that when the physical disabilities are relieved, the unnatural disposition of these children improves.

Speech is frequently delayed in these subjects, or articulation is absent. In the milder degrees of the affection, children begin to speak during the fourth or fifth year, and they gradually improve, but there often remains a lisp or considerable hesitation.

Thirty to fifty per cent of the cases have strabismus of the convergent variety, and some difficulty of swallowing is noticeable. Convulsions are commonly met with in the severer forms of the disease, being present in more than half the cases. Their occurrence should be carefully noted; and the writer does not think it advisable to operate, unless they have ceased for three or four years.

Prognosis.—In the severe forms of cerebral diplegia the disease is rapidly or slowly fatal, more especially if there is excessive general rigidity. If there is only paraplegia or slight general rigidity the condition is non-progressive, and may tend to improve. It is stated by Petersen[1] that "paraplegic or diplegic patients usually die before the twentieth year; and that few of

[1] *Trans. Amer. Orth. Ass.*, 1900, vol. xiii.

those who are hemiplegic reach the age of forty." Our experience, however, does not agree with this sweeping statement, and we think that Petersen's observations must apply to the extreme cases accompanied by idiocy.

Treatment.—After this review of the affection in its various grades, and from an extensive experience in dealing with the disease, we are convinced that a very fair proportion of these cases are capable of much improvement by mechanical means, operation, and by careful training. From medical measures we have nothing to expect save indirect results, and the scanty remarks on the treatment of spastic paralysis in children in medical works bear out this statement.

The Cases which are and are not Adapted for Surgical Treatment.—A *suitable subject* for surgical treatment is a child or young adult of fair intellectual development, who has had no fits for the last three or four years, and is suffering from secondary contractures in the limbs due to the excessive action of the flexors, such contractures being clearly capable of relief. The patient should be amenable to discipline and training.

The cases which are entirely *unsuitable for treatment* are the idiotic, the microcephalic, and the violently irritable type of diplegic, subject to fits, to active athetotic movements, and to convulsions. A patient who has no control over his sphincters is also unsuitable. Another class of case not hopeful for treatment is where the affection of the hands and arms is of such a kind as to hold out slight hope of their assistance to the lower limbs in walking with crutches. That is to say, when the paralysis is complete, or spasm of the hands and arms never relaxes, treatment is of little avail.

It is important to recognise the length of treatment required. Active treatment will occupy several months, and it is unwise to undertake a case in a hospital for a month or two, and then send it back to a miserable home. Even after active treatment on the part of the surgeon has ceased, massage, skilfully directed exercises, with careful and thorough education of the muscles in acquiring new movements, must be carried out for some years.

The *principles* upon which we operate are these. It is quite certain that a paralytic muscle, constantly overstretched, will not tend by itself to spontaneous recovery. If this adverse factor is removed, and the weakened muscles be relieved of their tension and placed at rest, they rapidly recover. To take a simple example. By dividing the tendo Achillis and bringing the foot to the right angle, the extensors on the anterior aspect of the leg are no longer overstretched. They are placed in a state of rest, are therefore in a position of recovery.

There is also a further principle involved. We take it that the excessive reflexes are indicative of the over-excitability of the central nervous system, and the important point is, if possible, to allay this excitement. We know too that the tension of a muscle is reflexly dependent, through the spinal cord, upon the tension of its tendon. There are nerve-endings in it which, when excited, send stimuli to the spinal cord, and these are reflected to the muscles. Now if the tendon of a tightly contracted muscle is divided, the reflex stimulation ceases, the vicious circle is broken, and the muscle is no longer tonically contracted. It may be said that all this is hypothetical; that the good results of tenotomy are merely mechanical, and entirely due to the lengthening of the tendon. We have, neverthless, indisputable evidence of improvement in the general bodily and mental condition of patients after section of the contracted structures. Therefore, the practical deduction from these observations is that we are justified in performing tenotomies in cases of the types we have already described as suitable, whenever spastic contractions exist.

The **treatment** of infantile spastic paralysis falls into three divisions: the pre-operative, the operative, and the post-operative.

In the *pre-operative stage* the greatest care is taken to maintain the nutrition of the muscles, and particularly of those which are not affected by the spasm, so as to maintain them at their highest possible development, and enable them to neutralise, as far as possible, the persistent spasm of their opponents. Dry warmth is very useful, and much relaxation of spasm can be obtained by exposing the limbs to the heat of a fire for half an hour to one hour before massage is given, taking care, of course, not to run any risk of scorching. Active and passive movements are more free in the morning. Later in the day the movements become restricted, irregular, and difficult.

Deformities in this disease arise in the first place from overaction of the spastically affected muscles; and in the second place, as in infantile paralysis, they are due to contracture, gravity, and perverted movement. Therefore it is advisable to control the movements and guide the limbs in the right direction by apparatus. As a simple instance, a steel support with a toe-uplifting spring should be advised for those cases where some limitation of dorsiflexion is present, due to partial contraction of the tendo Achillis; the equinus deformity is arrested and improved, and the patient soon walks toe and heel on the ground.

Particular attention is to be devoted to the education of the child in the performance of movements in the normal directions. The contracted muscles are stretched daily by passive manipulations. When there is spasm of the forearm and wrist and fingers, gradual extension of the wrist may be brought about by the use of a malleable iron splint, of which the angle is increased from time to time, but only very gradually (Figs. 335, 336, 337, p. 617). The most difficult part of the treatment of the forearm is to secure supination, and special means have been devised to attain this object. In what way the improvement arises it is difficult to say, but it certainly appears as if prolonged fixation of spastic muscles, in positions opposed to their contraction, gradually lessens the severity of the spasm. It seems as if the muscles at last became tired of "trying to pull."

If the case be a mild one, mechanical and manipulative treatment extends over twelve months. In many of the milder cases of spastic paralysis, treatment carried out on these lines will effect marked improvement. When spasm and contracture fail to yield, we are compelled to resort to operative measures.

Operative Measures

(*a*) **In the Upper Extremity.**—When the condition is one of infantile hemiplegia the arm is more affected than the leg, and in cerebral diplegia the spasm is more marked. As a rule, the treatment of the hand and arm in infantile hemiplegia is not so promising as in a monoplegic case. The most pronounced deformities of the hand and arm are flexion of the elbow, pronation of the forearm, flexion of the wrist and fingers. We have, however, seen cases of cerebral diplegia in which the upper extremities were rigidly extended.

The operative procedures on the upper extremity consist of tenotomy, tendon-transplantation, and lengthening of tendons. In all cases it is best to commence by relieving the spasm of the flexor tendons at the wrist, remembering that in spastic conditions there is a danger of over-correction.

In my earlier operations I was content with the following method. A longitudinal incision was made just above the wrist, over the median nerve, which was isolated. With a blunt-pointed tenotomy knife the contracted tendons were severed, care being taken to proceed carefully, so as to avoid the radial and ulnar arteries and nerves. The danger of over-correction was met by keeping the wrist and fingers flexed for three weeks, and then gradually extending them on a malleable iron splint. At the end of six weeks the wrist and fingers were in the mid-position, and were maintained so for a further six weeks, when movement was encouraged. Stiffness of the fingers was prevented by daily movements in the direction of flexion.

In order to shorten the treatment, I have lengthened the tendons at the wrist by the Z-shaped method. The operation is a tedious one, because care must be taken to join the proximal end of each tendon to its distal end, and not to cross them; otherwise there is a risk of matting and loss of movement. I use sixteen small discs of metal, and have two labelled S 1 and S 1, two S 2 and S 2, two S 3 and S 3, two S 4 and S 4; likewise, two P 1 and P 1, and so on.[1] Before each tendon is divided, a silk suture is passed through above and below the line of incision; and in the case of those portions of the sublimis tendon going to the index finger the two discs labelled S 1 and S 1 are attached, and so with the other tendons. In joining up the tendons there is, therefore, no confusion, as each one of a pair of metal discs corresponds with the other. Sections through the tendons having been made by the Z-shaped method, the fingers are extended to the mid-position between flexion and extension, and the tendon ends sutured.

In order to overcome the spasm of the carpal flexors, Robert Jones transplanted the flexor carpi radialis and the flexor carpi ulnaris to the dorsal surface of the bases of the second and fifth metacarpal bones. When the tendons have not been long enough to reach the new insertion, as is frequently the case, I have used Lange's method of prolonging them by silk.

As an instance of the success of this form of treatment I append the following case of a gentleman, aged 26 years, who came under my care for a contracted and entirely useless spastic right hand.

CASE 25. *Operation for Spastic Contraction of the Right Hand.*—The tendons of the flexor sublimis and profundus digitorum, and the flexor longus pollicis were lengthened at the wrist by the Z-shaped method.

[1] S 1 to S 4 correspond to the four slips of the sublimis tendons, and P 1 to P 4 to those of the profundus.

Subsequently, the carpal flexors of the right wrist were divided, their tendons lengthened by means of silk attachments, and then transferred to

post-card, that I send
back to you

FIG. 428.—Specimen of Writing, of a patient, after operation by the author, whose right hand was contracted after Cerebral Hemiplegia. The flexor tendons were divided and lengthened, and the carpal flexors were transferred to the extensor surface of the wrist.

the extensor surface of the bases of the second and fifth metacarpal bones. Whereas, before the operation, the patient's right hand was useless, and

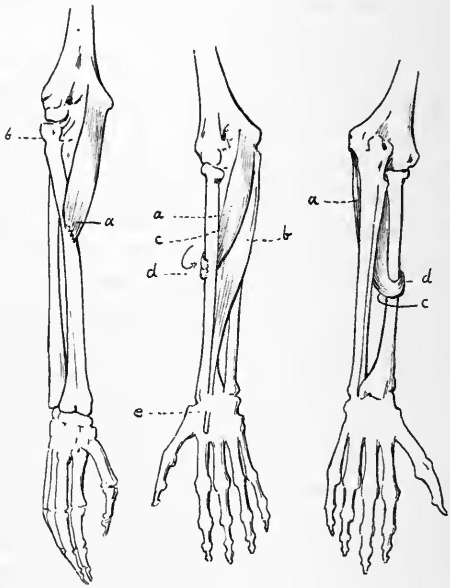

FIG. 429. FIG. 430. FIG. 431.

To illustrate a method of Transforming the Pronator Radii teres into a Supinator. a= pronator radii teres, in Fig. 429, passing, in its natural course, to its insertion on the radius.

In Fig. 430 the tendon has been detached, and has been passed *behind* the radius to its outer side. c is the opening in the interosseous membrane through which the tendon is passed, and it is reinserted at d. At e the flexor carpi radialis has been divided.

FIG. 431 is a posterior view of Fig. 430, but in Fig. 431 the pronator radii teres is drawn too low down on the radius.

he could only passively extend its fingers with the left hand, he is now able to use it in dressing himself. Six months after the operation he was engaged as a clerk in a bank, and writes moderately well with the right hand. A specimen of his writing is given (Fig. 428.)[1] The patient wrote me to this effect: "Nearly every movement, which I can perform now with the right hand, I could not do before."

To relieve the flexion of the elbow and the excessive pronation, simple tenotomy of the biceps is not only useless, but harmful, for the biceps is the great supinator of the forearm, and its action should be carefully preserved. Inasmuch as some of the flexors at the elbow are also pronators, such as the pronator radii teres and the flexor carpi radialis, it appears that if they are divided, the flexor spasm and the hindrance to supination will be lessened. This is so, but it is not the entire problem. What is required is to add to the power of supination. Therefore in 1899 the author devised and carried out an operation whereby the excessive pronating power of

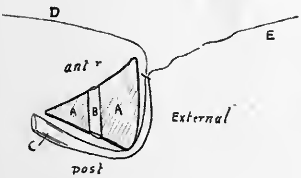

FIG. 432.

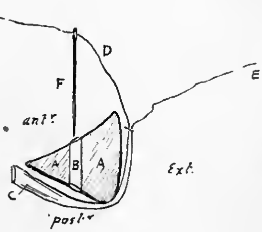

FIG. 433.

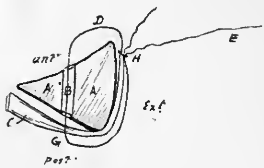

FIG. 434.

To show the method of Re-inserting the tendon of the Pronator Radii Teres on the outer side of the radius, after it has been detached and passed through the interosseous membrane. AA, section of radius; B, hole drilled through radius from before backwards; C, tendon of pronator radii teres; D and E, ends of silk attached to tendon.

In Fig. 433 a needle, F, is seen threaded on one end of the silk D, and the needle is in a position to be passed through the hole B in the radius, and therefore through the tendon C.

In Fig. 434 the thread D has been passed through the radius, and the tendon at C, and is knotted at H.

these two muscles was not only neutralised, but made to add to supination, and he has since described this operation.[2]

Important modifications, however, have been introduced. The pronator radii teres and the flexor carpi radialis are defined, and the tendon of the latter severed $1\frac{1}{2}$ inches above the wrist. The pronator radii teres is put at full stretch and is joined to the proximal end of the flexor carpi radialis as low down as possible. The conjoined tendon is then pulled through the interosseous membrane, carried round the back of the radius, and inserted on

[1] Hunterian Oration, fig. 8.

[2] *Surgery of Paralyses*, p. 220.

its outer side (Fig. 436). A second modification consists of section at the same time of the interosseous membrane throughout its entire length; as it has been found that, while intact, it prevents full supination.

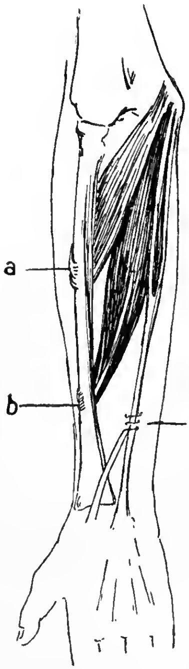

Fig. 435.

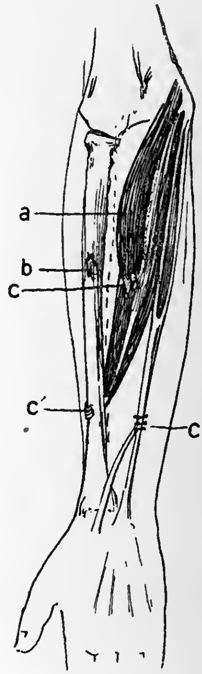

Fig. 436.

Fig. 435.—To illustrate the author's latest methods of dealing with Pronation of the Forearm in Spastic Paralysis. The pronator radii teres and the proximal end of the flexor carpi radialis are brought round the *back* of the radius, and re-inserted on the outer side, in the same way as in Figs. 432, 433, 434, likewise the interosseous membrane is divided throughout its entire length. *a*, pronator radii teres tendon passing behind radius. *b*, flexor carpi radialis, passing behind radius and inserted on its outer side. *c*, distal end of flexor carpi radialis tendon attached to palmaris longus.

Fig. 436.—A modification of the procedure seen in Fig. 435. In some cases, on account of the shortness and absence of definition of the pronator radii teres tendon, it cannot be satisfactorily drawn round the back of the radius and re-attached. It is therefore cut away from the radius at *b*, and sewn to the flexor carpi radialis at *c*. The flexor carpi radialis tendon is then divided, drawn through the interosseous space, round the back of the radius, and inserted on its outer side at *c′*. *a*, pronator radii teres, *c″*, distal end of flexor carpi radialis tendon joined to palmaris longus (A. H. Tubby).

The steps of the operation are as follows: An incision about six inches long is made in the middle three-fifths of the forearm, over the line of the radial artery. The inner margin of the supinator longus is then defined, and this muscle separated from the flexor carpi radialis. The radial vessels and nerve are found and drawn well to the inner side. The pronator radii teres is then sought for, the direction of its fibres affording a guide. It is a broad muscle with a short flat tendon, which rapidly merges into the periosteum of the radius. The upper and lower margins of the muscle are well cleared, and the tendon, with some periosteum, is detached from the bone. The flexor carpi radialis is then separated from its neighbours, and its tendon divided, about $1\frac{1}{2}$ inches above the wrist. Both it and the pronator radii teres are placed on the stretch, and the latter is sutured firmly to the former (Fig. 436). The next step is division of the interosseous membrane. We find the flexor longus pollicis, and then completely sever the membrane with a tenotomy knife, taking care to avoid the anterior interosseous artery and nerve. Through the space so made, the conjoined tendon is brought round to the back of the radius. An aneurysm needle is passed through the interosseous space and round the outer side of the bone. By working the aneurysm needle rather vigorously in a vertical direction, the soft tissues are cleared away from its outer surface and the needle is withdrawn. A silk suture having been previously passed through the end of the conjoined tendons, one end of the silk is threaded through the eye of the aneurysm needle, now passed from the outer side, and the tendon is drawn through behind the radius. The aneurysm needle is now dispensed with. The next step is to refix the conjoined tendons, which is accomplished in the following way: A hole is drilled through the radius from front to back. One end of the silk ligature which has been passed through the tendon is threaded on a straight needle, the needle and silk passed from before backwards through the hole in the radius, and through the tendon now lying at the back of it, care being taken that the latter is pulled upon vigorously. The ends of the silk ligature are then knotted, and the tendon fixed in its new position (Figs. 432-4, p. 731). The limb is put up with the forearm supinated and the elbow flexed for four weeks.

The improvement effected by this operation, though of varying degrees, is always marked, and in five cases the power of supination was almost entirely regained, whilst the persistent flexion of the elbow was much diminished.

After-treatment consists of educating and training the limb in its new position. Passive movements are at first limited, so as not to stretch the bands of union unduly, and after the sixth week they are more extensive. Active movements are begun about the sixth week. The best way of re-educating the transferred muscles is to practise movements of supination of the forearms and extension of the elbows simultaneously with both limbs. Later, the sound limb may be tied up, so as to induce the patient to make every possible use of the affected member.

Whether an operation be performed or not in these cases, the final stages of treatment are identical. The parents or the guardian should be exhorted to spare no effort in urging the patient to practise the exercises from simple to complex. Their nature must be left to the ingenuity of the surgeon, but there are certain governing principles. They are, (*a*) the movements are practised slowly and without excitement; (*b*) they should be interesting to the child; (*c*) those movements

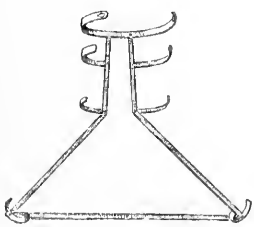

Fig. 437.

Fig. 438.

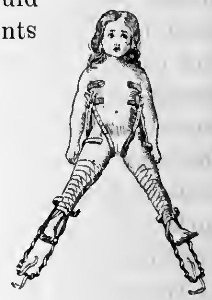

Fig. 439.

Fig. 437.—Abduction Frame for cases of Spastic Paraplegia (Jones).
Fig. 438.—Double Abduction Frame, with extensor arrangement for the legs (Jones).
Fig. 439.—The Double Abduction Frame, applied (Jones).

opposed to the production of deformity should predominate; (*d*) those presenting the greatest difficulty should be chiefly practised.

Treatment of the Lower Extremities.—In slighter cases, where there is merely slight contraction of the hips, an improvement may be effected by placing the patient on a double abduction frame (Figs. 437, 438, 439). The condition of the lower extremities in cases of spastic paraplegia frequently calls for operative interference when the patient comes under observation. The adductors of the thighs, the tensor vaginæ femoris, sartorius and ilio-tibial band are shortened and require section; and contractions at the back of the knees, and of the tendons Achillis are dealt with.

If there is reason to suspect that a series of operations such as we have mentioned will, if performed upon the child at one sitting, prove to be too much for his endurance, there is no objection to surgical interference in stages, beginning with the thighs and subsequently attending to the knees and feet. In every case, operating by the open method is strongly to be recommended.

We begin with the adductors. The skin of the groin and neighbouring parts having been suitably prepared, an incision $1\frac{1}{2}$ inches long is made on the inside of the adductor longus tendon, just below the fold of the groin. The tendon is then exposed and freed by passing a finger round it, and $\frac{3}{4}$ of an inch of it at least is exsected. The limb is then further abducted, and portions of the adductor brevis and gracilis are exsected in a similar way. It is often advisable to cut out portions of the adductor magnus and the pectineus; in fact, any and every tissue which limits free abduction should be dealt with on these lines. In carrying out this operation, the superficial branches of the obturator nerve are divided and pieces exsected.[1] Hæmorrhage is arrested, the wound is closed without drainage, and covered with collodion and gauze so as to render it urine-proof. The many advantages of this open method of removing parts of the adductors are obvious, as we effect by one stroke what takes months to accomplish by subcutaneous division and stretching, and, then only, with the probability of recurrence of the adductor spasm.

The limbs are kept fully abducted during the whole time of healing; for, even if we exsect portions of the muscle substance, it is astonishing how quickly scar-tissue forms and how obstinate it is to manipulation.

The sartorius, tensor vaginæ femoris, and the ilio-tibial band are attacked in the same way, by the open method. The contractions at the knee are now dealt with, and the skin-incision should in every case be longitudinal over the tendons and not transverse. As a rule, one incision on the outer and a second on the inner side suffices. By burrowing through the subcutaneous tissue, the tense deep fascia between the incisions can be reached and completely divided. The hamstrings are severed, or a portion exsected, if need be.[2] Finally the tendo Achillis is elongated by the Z-method, and the patient is stretched comfortably upon an abduction frame, or in a suitable arrangement of calliper splints (Figs. 440, 441, 442), with the lower extremities fully abducted, the knees straight, and the feet at right angles.

[1] We hear that Mr. Stansfield Collier has divided the obturator nerve above the groin in these cases.

[2] Exsection of portions of the hamstrings was first practised, we believe, by Mr. R. Jones in 1885 and of the adductors in 1896.

At the end of three months, the splint is taken off during the day and movements are regularly practised. At first they are painful, but discomfort ceases after a short time and the patient makes efforts to walk. Active movements should be carried out under the guidance of a trained nurse or an intelligent parent. The surgeon imparts instruction as to the character of the exercises and maintains general supervision of the later stages of treatment. The most important active and passive movements are flexion of the hips, rotation outwards, full abduction in this position and then complete extension of the limb at the hips and knees. At first, the

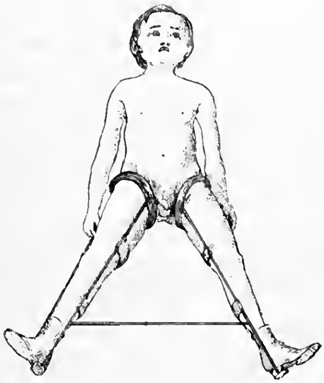

Fig. 440.

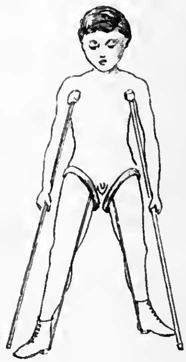

Fig. 441.

Fig. 442.

Fig. 440.—Apparatus designed to maintain abduction after operation for Spastic Paralysis. It consists of two Thomas' knee-calliper splints, with an adjustable cross-piece (Jones).

Fig. 441.—The after-treatment of Spastic Paralysis. Calliper splints fitted to enable the patient to walk (Jones).

Fig. 442.—Scheme for maintaining the abduction of the limbs at night, after operation for spastic paraplegia (Jones).

movements are carried out passively by the attendant and later the patient performs them actively.

The surgeon also orders splints of a simple kind designed to prevent the knees from bending. The boots are made of felt with substantial soles, and the nurse is instructed to keep the boots and splints upon the patient day and night. During sleep, the feet are to be attached to the sides of the bed so as to maintain abduction (Fig. 442). Twice a day all the muscles of the lower extremity should be massaged, particularly the abductors of the hips, the extensors of the knees and the dorsiflexors of the feet. One valuable result of the operations and subsequent procedures is that, the adduction of the thighs being entirely overcome, the child acquires a wider basis of support for the trunk.

The special points of direction given to the nurse as to walking are: any simultaneous swing of the lower limbs is to be prohibited, and therefore crutches are not permitted until the patient has been taught to stand unsupported. During the early stages of walking, the nurse sees that the limbs are not approximated; every step is elaborately perfected, the feet being maintained at a proper distance apart, the knees extended fully in walking and the toes and heels coming in contact alternately with the ground.

As to the good results accruing from the operative treatment: When the parents have been informed that the case is deemed suitable for surgical treatment, they should be told that the surgeon can only enter upon it with the clear understanding that he shall have every opportunity and facility of supervising the after-treatment. If such an understanding be arrived at, experience teaches us that a child, with the aid of sticks, will be able to walk a considerable distance in twelve to twenty-four months, and that with perfectly straight limbs and toes and heels on the ground. Later on, many cases will eventually be able to dispense with all kinds of artificial aids.

Apart from the improvement in the physical condition, we insist on another important point: with the change for the better in the physical condition, the mental state improves in an even greater degree. The reasons are two: the first is that improved range of movement in the limbs and greater powers of locomotion imply a closer contact with persons and things, and the mental outlook is widened. The second is that, the cessation of perpetual irritation and stimulation, due to contracture and spasm at the periphery of the nervous system, results in the brain being less occupied, less perturbed, and therefore more responsive to outside impressions.

To sum up the treatment of spastic paralysis. It involves three stages: the operative, the mechanical, and the educational; and the patient must be under the surgeon's control for at least twelve months, with an organised system of after-education, carried out by specially trained nurses—the type of education being of the practical as opposed to the second-hand and abstract type.[1]

There are a limited number of cases of a mild type where no

[1] It is most desirable that scholastic institutions for the care of paralytic children of all types and classes be instituted in this country; and we are glad to welcome efforts which are being made in this direction.

operation save section of the tendo Achillis is needed. Usually, however, the adductors should be stretched on a double abduction splint for several weeks, in the recumbent position. This position is maintained until by appropriate exercises the patient is able to put the hip-joint through its usual movements, without spasm. Afterwards, he walks for several months with fixed knees. Knee-splints, to prevent flexion of the knees, are in most cases indispensable at night for a year after the abduction splint is discarded.

By day, it is advisable to use an apparatus to control the limbs, as the patient often shows a strong inclination to revert to the vicious manner of walking. It consists of a pelvic band with the hip-pieces well abducted, flexion joints opposite the hips, ring-catches at the knees and double knee-caps, and a flexion-movement at the ankles. If there are signs of return of contraction at the knees, the ring-catch joints are locked, and the patient goes about with temporarily fixed joints. Sometimes, the pelvic band can be dispensed with, and an apparatus supplied which reaches no higher than the thighs.

The treatment of spastic paralysis on these lines is encouraging, and it is a distinct reproach to surgery that such cases are so often left to the care of the masseur, in the hope that Nature will eventually do something towards their cure.

Recently, other measures have been used in the treatment of this distressing affection. They comprise muscle and tendon transplantation and nerve transference.

Muscle grafting and tendon transplantation have been performed chiefly about the knee-joints, transferring flexors or a portion of them to the extensor aspect; and, some fairly satisfactory results have been reported. Great care is required in the selection of cases for this operation. We are not dealing with normal or paralysed muscles, but with those which are in varying states of spastic contraction; but, there is a distinct risk of overdoing matters and of setting up spastic contractions in the direction opposite to that where they previously existed. Still, the improvements noted are such that the operations are worth consideration.

Bold attempts have been made to overcome the spasticity of groups of muscles, especially the flexors and promoters of the upper limb, by *complete nerve-crossing.* From private sources we hear that Spitzy of Graz has done this once with a measure of success. We append published notes of another case:—

Messrs. Spiller, Frazier, and Van Kaathoven [1] have performed a pioneer operation for athetosis. "In this distressing affection the flexors are usually more powerful than the extensors in the upper limbs. It occurred to one of the writers—Spiller—that if he could switch off, so to speak, some of the excessive innervation of the flexors into the extensors by nerve-transplantation, he might be able to establish a more nearly normal relation between certain groups of muscles and their opposers, and he might by division of nerves be able to lessen the athetoid movements, probably permanently; whilst it seemed hardly likely that restoration of function would be so perfect as to permit a return of athetoid spasms. Nerve-operations were carried out in a case, where the athetoid movements in the upper extremity had been very violent for several years. As early as two and a half months after the first operation, the condition of the patient was so much improved that he was satisfied with the result, and stated that he had never in his life been so comfortable. The operation consisted of lateral anastomosis to the musculo-spiral of the divided median and ulnar nerves. The second operation consisted of section of the musculo-cutaneous and circumflex nerves, and suturing the central end of one to the distal end of the other, and *vice versa*. So that a crossing of the nerves of the upper extremity was effected. These operations removed, at any rate for a time, by a partial paralysis, the athetosis, and the latter can only return with the disappearance of the paralysis. An objection will be raised that the operation is an attempt to influence a cerebral lesion by disturbing the peripheral nerves. This is precisely what it is. If the distressing peripheral effects are removed, the cerebral lesion becomes of very little account. It might have been supposed that impulses sent from the motor tracts, having been arrested in the upper limbs, would flow over into fibres destined for innervation of the lower limbs, or that some evidence of discomfort would be observed, but nothing of the kind occurred in the case under notice. A good deal of movement was ultimately regained in the limb, and the results of the operation were most encouraging." My colleague, Dr. Purves Stewart, informs me, however, that he saw this case when he was in Philadelphia. He offered the objection mentioned above, and he considered that the result of the operations was disappointing.

Förster's operation of section of the posterior nerve roots of the affected nerve trunks is still on its trial.[2] An abstract of his address at the Royal Society of Medicine in June 1911 is given in Appendix IV. of this volume.

[1] *Am. Journ. of Med. Sciences*, March 1906.

[2] Cf. Codivilla, "Über die Förster'sche Operation," *Münch. med. Wochenschr.* No. 27, 1910. Also F. Rose (*La Semaine médicale*, July 7, 1909) reviews Förster's operation, and discusses the indications and contra-indications. Förster's original communication is in *Zeitschr. f. orth. chir.* Bd. xxii., Sept. 1-3, 1908.

CHAPTER V

PARALYTIC DEFORMITIES FOLLOWING INJURIES TO NERVES

Accidents to and Pressure on Nerves—Classification and Treatment of Nerve-Injuries—Primary and Secondary Operations on Nerves—Prognosis and Treatment—Traumatic Paralysis of the Facial and Spinal Accessory Nerves—Of the Brachial Plexus—Birth Palsy or Obstetrical Paralysis—Paralysis, Partial and Complete, of the Lumbar and Sacral Plexuses.

THE surgery of deformities in this class of cases[1] forms no inconsiderable proportion of orthopædic work, and the cases are of great importance, partly because of the effects of the injuries on the patients, partly on account of the actions-at-law which arise from the Employers' Liability and Workmen's Compensation Acts.

The *causes* of nerve injuries are three: wounds, accidental or operative; pressure, and traction.

Accidental wounds of nerves mostly occur in the region of the wrist or lower part of the forearm, and the tendons are often severed simultaneously. The median nerve suffers most frequently, and both it and ulnar are often divided at the same time. The nerves, most liable to injury during operations, are the spinal accessory, the branches of the cervical plexus, the facial nerve, the nerves of the abdominal wall, and the posterior branches of the lumbar plexus.

Pressure on Nerves.—Dislocation of the shoulder is sometimes complicated by injury to the brachial plexus; mainly, because the displaced head of the humerus bruises and presses on the nerve-cords. The damage done largely depends on the degree of force transmitted through the dislocated head; a single nerve-trunk may be bruised, or the entire plexus ruptured. The

[1] For much information on this branch of the subject I am indebted to Mr. James Sherren, whose views are so ably set forth in *Injuries of Nerves and their Treatment.* London, 1908; also "Some Points in the Treatment of Nerve Injuries," *Lancet*, Jan. 15, 1910.

dislocation most frequently productive of injuries is the subcoracoid. The biceps muscle, however, being supplied through the fifth or fifth and sixth cords, often escapes, when the other muscles are paralysed.

The heel-in-the-axilla method of reduction of the dislocation is sometimes accountable for brachial paralysis, especially when the boot or shoe is not removed. Dislocation of the elbow sometimes involves the ulnar nerve. This injury is nearly always recoverable, although there are cases recorded where the rupture was complete. After dislocation of the hip, the great sciatic nerve has been found permanently paralysed in two cases. In both, the displacement had lasted for several days, and considerable traction force had been exercised. Paralysis of the whole sciatic nerve, and in a larger number of cases of the external popliteal, has occurred after the reduction of congenital dislocation by Lorenz's method.

Paralysis is not uncommon as a complication of fracture, the most frequent examples being found in the upper extremities. The loss of power may come on immediately after the injury or, sometimes, later; if immediate, it may be temporary or permanent. If temporary, it is due to pressure of a dislocated fragment, pressure on vessels, hæmatoma, or tight bandaging. The most typical example of pressure by a dislocated fragment is involvement of the musculo-spiral nerve in fracture of the shaft of the humerus. Another example is paralysis of the popliteal nerves, on separation of the lower epiphysis of the femur.

Permanent disability follows rupture of a nerve, and, sometimes, its function may be irretrievably lost by crushing or prolonged pressure. The paralysis which comes on late may be illustrated by "crutch-palsy," and by the involvement of a nerve in adhesions or in callus. Post-anæsthetic palsy and paralysis of sleep are also examples of pressure-effects.

Paralysis due to Traction or Over-stretching.—The brachial plexus affords the chief examples of this group, particularly birth-palsy. Indirectly, prolonged extension and the manipulations for reduction of congenital dislocation of the hip cause traction on the sciatic nerve and loss of power, happily often temporary.

Gunshot wounds divide nerves or cause pressure on them by displaced fragments of bone.

Classification of Nerve Injuries.—Sherren divides them into complete and incomplete division; and, he points out that in each case the continuity of the nerve may be anatomically interrupted, or its function may be so suppressed as to constitute a physiological interruption.

Symptoms.—The coarse symptoms are apparent to everyone; but the greatest care is necessary in the examination to distinguish whether the nerve is completely or partially divided; whether it is hopelessly damaged or is presenting signs of recovery; if surgical intervention is necessary, and the exact form which it should take. Particular attention should be given to the loss of sensation, and we are indebted to the observations of Head and Sherren on this point. They distinguish sensation to light touch, to pricks, and deep sensation; and they use the terms "epicritic" and "protopathic" as synonymous with sensation to light touch and pricks. The electrical reactions, at the time of seeing the patient, require extreme care in testing, as erroneous conclusions are so often drawn from imperfect examination. These points are fully dealt with by Sherren in his work, and careful study of the first six chapters of his book are of the greatest assistance.

Treatment of Nerve Injuries.—If rupture of a nerve is diagnosed and paralysis is complete, primary suture is to be attempted. If paralysis is incomplete, and there are signs of power returning in the nerve, operation should be delayed until the amount of residual paralysis is ascertained. If this be extensive, operation is called for; but, *cæteris paribus*, the longer the operation is delayed, the less satisfactory is the prognosis.[1] So soon as the condition of the part ceases to improve, we should interfere surgically.

When pressure is due to malposition of fragments, a wiring operation is required; and if the nerve is involved in callus, it should be dissected free of the new material.

After a nerve-operation, the part is put up in such a way that the nerve and muscles are relaxed and kept so, until voluntary power is restored. Massage and passive movements, with the use of the faradic current to the nerve, are called for daily, and the paralysed muscles may be stimulated by the constant current. After voluntary power has returned sufficiently to cause the muscles to act, supports are removed; nevertheless, the other details of treatment should be continued until the action of the affected

[1] Cf. Sherren, *Lancet*, Jan. 15, 1910. He points out that with primary suture of injured nerves, the prospect of recovery is much better than after secondary; and he adds that in primary suture there are three details requiring attention: 1. The suture material should be of absorbable material, *e.g.* catgut. 2. The wound in the nerve must be protected by cargile membrane. 3. For wounds in the region of the wrist the fascia must be united separately.

muscles is normal. After-treatment, therefore, must occupy some months at least.

Operations on nerves may be either primary or secondary. By primary, is meant operating at the time the nerve injury is caused; and by secondary, operation at a later date.

Primary Operation of Nerves.—There are some situations very liable to incised wounds, such as the wrist, where the nerves are occasionally divided; and an electrical examination of the muscles of the hand should be made so as to ascertain if the nerves are involved. Any suspicion can be confirmed by carefully dissecting down upon the nerves. If one or more nerves are found incompletely divided, then a catgut suture is inserted so as to draw the torn parts of the sheath together: The wound is most thoroughly cleaned, as sepsis interferes as much with nerve-union as with tendon-suture.

If the nerve is completely divided, it should be joined, which can be done at once if the cut is clean. When the ends, however, are lacerated they must be trimmed with a sharp knife and united by catgut. Sherren remarks that a single catgut suture should be passed through the whole thickness of the nerve at right angles to its axis and tied with force just sufficient to bring the ends into position. The junction should be surrounded with chromicised cargile membrane.[1]

Secondary Suture is called for after subcutaneous injuries arising from the pressure of bone fragments, from traction on the nerves, and after suppurating gunshot wounds.

Before an operation is undertaken, a thorough investigation should be made of the functions of the part and any secondary deformities reduced. In secondary suture, the ends of the divided nerve are found, the bulb on the proximal portion and the bridge of fibrous tissue uniting the two ends removed, and the ends of the nerve drawn together; this may often be accomplished by pulling moderately upon the proximal end of the nerve and flexing the joints. Catgut is the best material for suture, and, if it is hardened so as to resist absorption for fourteen days, it acts very satisfactorily. It is useless to leave the joined nerve in the middle of fibrous tissue. We must dissect the latter away and surround the junction with cargile membrane or silver foil. In some cases it is better, if possible, to transfer the united nerve to a new situation between muscles or into subcutaneous tissue. After closing the wound, the limb should

[1] Cargile membrane is the prepared mesentery of the ox.

be secured in splints so that there is no tension whatever on the nerve.

When it is impossible to bring the two ends together, various methods of bridging the interval have been used. The first successful case of this kind was by Mayo Robson.[1] He excised a neuroma from the median nerve, and into the $2\frac{1}{2}$-inch gap so made he inserted a piece of the posterior tibial nerve from an amputated leg.

The methods by which re-union have been attempted are—(*a*) The employment of extraneous material such as catgut threads, decalcified bone, specially prepared arteries of animals, or a resected portion of one of the patient's superficial veins.

(*b*) Nerve transplantation. Merzbacher[2] has divided the methods of nerve transplantation into three groups:—

1. Auto-transplantation, where a nerve from the same animal is used.

2. Homo-transplantation, where a nerve from an animal of the same species is used.

3. Hetero-transplantation, where a piece of nerve from an animal of another species is used.

Kilvington has experimented with the object of determining the relative value of these methods,[3] and his conclusion is that auto-transplantation is immeasurably superior to all other methods, particularly in primary operations. Auto-transplantation can be carried out in man. Mr. Henry Dean, in 1896, used the patient's radial nerve, inserting three inches into a gap in the musculo-spiral, and the operation was successful. It is found that the upper two-thirds of the radial nerve may be removed without causing any marked effect upon sensation. Sherren states that four inches of nerve have been used in this way, and recovery ensued. If the space required to be filled is greater than this, it would probably be wiser to resort to anastomosis. Kilvington suggests that the internal saphenous nerve of the leg may readily be sacrificed for nerve-bridging or gapping. A considerable length of it is available, and one or more thicknesses can be used. A gap in the ulnar nerve would require at least three widths of the saphenous nerve and the sciatic many more.

If it is found that auto-transplantation is impossible, or if it has

[1] *Brit. Med. Jour.*, Oct. 31, 1896.
[2] *Neurolog. Centralblatt*, Bd. xxi., Leipzig, 1905.
[3] *Brit. Med. Jour.*, Jan. 13, 1908.

been tried and failed, we must consider the propriety of two other operations.

1. Nerve-anastomosis, in which the axis-cylinders of the injured nerve are brought into contact with some of the axis-cylinders of a sound nerve.

2. Nerve-crossing, in which a sound nerve is divided completely across, and the peripheral part of the paralysed nerve is united to the proximal segment of the sound nerve, end to end. This subject has been considered in the section on "Infantile Paralysis" (pp. 656-9).

In nerve-transplantation it appears to matter little whether we use a sensory nerve to bridge a gap in motor nerves, or whether we insert the piece of sensory nerve in a direction totally opposite to its natural impulse.

Prognosis.—The prognosis of primary suture, provided that no suppuration occurs and thorough after-treatment is carried out, is extremely satisfactory. The outlook, after secondary suture, is not so good. Some residual paralysis is occasionally left, and sensory recovery is not always complete. The less the interval between the accident and the time of suture, the greater the chance of recovery, and the quicker it occurs. Sherren[1] is of opinion that the delay in recovery depends upon the method of healing of the accident wound, suppuration retarding the date at which the first stage of recovery commences. He thinks, too, "it is probable that in patients in whom the nerve has been divided for a long time, and the muscles retain their irritability to the constant current, nerve-anastomosis is more likely to be satisfactory than secondary suture."

We pass on to the consideration of deformities arising in connection with individual nerves or groups of nerves. Of the cranial nerves, the facial and the spinal accessory are the most important.

Paralysis of the Facial Nerve

Some cases arise from injury, accidental or operative, or from pressure of forceps, others are due to middle ear disease, and a third class belong to the so-called rheumatoid type. Occasionally the nerve is ruptured or pressed upon in fracture of the petrous portion of the temporal bone.

The symptoms vary according to the site of the nerve-injury, more particularly in its relations to the chorda tympani. When the facial nerve is injured above its junction with the chorda tympani,

[1] *Injuries of Nerves*, p. 115.

the auditory nerve is usually implicated at the same time, and the effects on the muscles of the face are similar to division of the nerve after the chorda tympani has left the facial. Some authorities state that there is also paralysis of muscles of the soft palate. Others have not confirmed this observation.

If the facial nerve is injured where it is accompanied by the chorda tympani, there is a loss of taste over the anterior two-thirds of the tongue on that side. And, lastly, when the injury occurs in the petrous bone, after the chorda tympani has left it, or is extra-osseous, the typical symptoms of Bell's palsy are present.

Recovery takes place in most of the rheumatic cases, and an opinion may be hazarded as to the recovery in other cases by

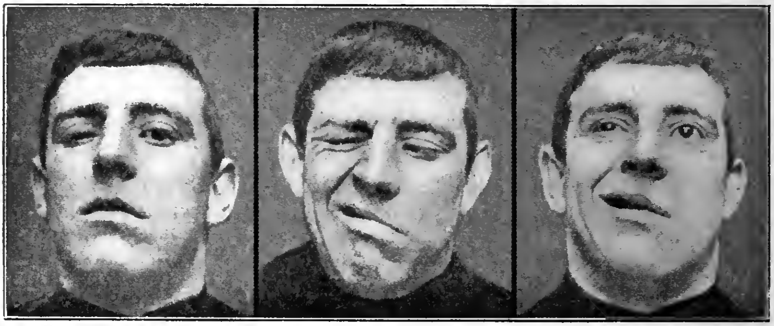

FIG. 443. FIG. 444. FIG. 445.

Three figures, illustrating a case of left Facial Paralysis, under the author's care in Westminster Hospital, before the facio-hypoglossal anastomosis was carried out.

noting the results of electrical testing of the muscles. If reaction of degeneration is present, recovery except by operation is unusual.

Treatment.—If the nerve is divided outside the skull by a penetrating wound, a primary suture should be done. If paralysis arises from middle ear disease, that condition must be at once surgically attended to. When there is evidence, however, that the nerve has been completely severed, and if reaction of degeneration is present in the facial muscles, nerve-anastomosis should be carried out. In the earlier operation, the distal end of the facial was grafted into the spinal accessory. This method is open to the criticism that, at first, associated movements of the face and shoulder are marked; later experience,[1] however, shows that independent voluntary and emotional movements return. It is to

[1] Purves Stewart, *Westminster Hospital Reports*, 1905, vol. xiv. p. 40.

Messrs Ballance and Purves Stewart that the credit is due of the first operation of facio-hypoglossal anastomosis. Notes of a successful case operated on by me are given in Vol. II. p. 660, and I crave permission to repeat them in this connection.

CASE 26. *Facio-hypoglossal Anastomosis for Facial Paralysis, following an Operation.*—A man aged 19 years was admitted under my care into Westminster Hospital on the 3rd of October 1905, suffering from facial paralysis which had followed the opening of a glandular abscess just behind the jaw. The surgeon had made a vertical incision six months previously, and completely divided the facial nerve, just behind the ascending ramus of the jaw. The left side of the face was completely paralysed, and there was no response whatever to faradic stimulation. The left

FIG. 446. FIG. 447.

Two figures illustrating the case of left Facial Paralysis by Facio-Hypoglossal Anastomosis, carried out by the author.

angle of the mouth dropped, the tongue deviated to the right, and he had lost the sensation of taste on the anterior part of the left side of the tongue. Epiphora of the left eye was present, and he dribbled somewhat from the left side of the mouth. He was unable to close the left eye at all, food accumulated in the left cheek; and, when he smiled, the mouth was drawn over to the right side. It was noticed that the hair grew more abundantly on the left than on the right side of the face.

Operation.—On October 16th an incision was made from the tip of the mastoid process to the greater cornu of the hyoid bone, and a dissection was undertaken to find the distal part of the facial nerve. It was evident that it had been severed subsequently to its division into its two main trunks, the cervico- and temporo-facial. With great difficulty these were found, and the hypoglossal nerve was then exposed. The digastric and stylo-hyoid muscles were removed, and the hypoglossal nerve pulled well up until it approximated to the distal facial trunks. Two small incisions were then made into the sheath of the hypoglossal nerve, the facial trunks were inserted and stitched in place.

The head and neck were fixed in plaster of Paris, so as to permit no tension whatever to be put upon the anastomosis.

One week after the operation, signs of recovery appeared. The patient could partially close the left eye. Gradually all the paralysed muscles recovered their power, and when the case was shown before the Royal Society of Medicine of London, in March 1909, it was difficult to distinguish which side of the face had been affected, except that there was a very slight droop at the left angle of the mouth. All movements and functions were perfect. It was also noted that there was a total absence of associated movements of the tongue and face, that the left half of the tongue was not wasted, and that the tongue could be protruded directly and without any deviation.

As a rule we should not wait more than six months after the reaction of degeneration has set in, before resorting to anastomosis.

The Spinal Accessory Nerve

This nerve may be divided in removal of glands, tuberculous or malignant, from the neck. When the nerve is cut before it enters the sterno-mastoid, paralysis of that muscle and of the upper part of the trapezius follows. The effects on the sterno-mastoid are comparatively slight, so far as the movements of the head are concerned. When section of the spinal accessory nerve occurs in the posterior triangle, branches of the third and fourth cervical nerves are often cut at the same time, and paralysis of the whole trapezius is seen. This constitutes a very serious disability and gives rise to most noticeable deformity. The shoulder is dropped, the scapula is rotated forward, it is tilted so that the glenoid cavity looks downward, and the patient is unable to raise the arm above the head, after it has been abducted by the deltoid, in a line directly outward from the body.

If, during operation, it is found that the spinal accessory nerve has been divided, it should be joined at once; if, as is more often the case, the symptoms of paralysis are found after the operation, secondary suture is necessary. If this proves to be impossible, then the peripheral end should be anastomosed to the anterior primary divisions of the third and fourth cervical nerves. This operation the writer accomplished with ultimate success in one case under his care at Westminster Hospital.

Injuries of the Brachial Plexus

This is a subject of considerable interest, and many cases have been recorded.[1] A convenient method of classification is supra- and infra-clavicular injuries and lesions.

The causes of supra-clavicular lesions are injuries during birth (birth palsy), indirect violence, such as a fall or blow on the shoulder or head, post-anæsthetic paralysis, and pressure from a cervical rib. Penetrating wounds and injury to the cervical spine also give rise to paralysis in the distribution of the branches of the plexus.

Infra-clavicular lesions usually arise from pressure of the dislocated head of the humerus or from fracture of the upper end of that bone or of the neck of the scapula. Reduction of dislocations by the heel-in-the-axilla method is responsible for some cases, and penetrating wounds and gunshot wounds for others.

Birth Paralysis (Obstetrical Paralysis)

Formerly it was considered that all the cases were due to compression; but recent investigations show that in the majority of cases the actual lesion is laceration due to over-stretching of the nerves and their sheaths. An excellent historical review of the subject will be found in an article by Clarke, Taylor, and Prout,[2] wherein the question of pressure *versus* laceration is carefully studied; and, it is shown how opinion has oscillated between the two views. Full references are given in the article.

Reviewing the literature, however, it is evident that with very few exceptions obstetric paralysis is due to manipulation in delivery. As a rule, birth palsies affect the upper limbs more frequently than the lower; and it is only very rarely that total paralysis has been reported.

Ætiology.—Any disproportion between the size of the child and the measurements of the maternal pelvis, especially such as hinder the rotation and descent of the shoulders after the birth of the head, is likely to provoke traction-efforts, which may be followed by paralysis. In fact, it occurs in about 1 in 2000 births, and

[1] Cf. "Traumatic Lesions of the Brachial Plexus and its Component Roots," C. K. Mills, *Trans. Pennsyl. State Med. Soc.*, 1910.

[2] *Am. Journ. of Med. Sci.*, Oct. 1906.

equally in vertex and breech presentations. Whilst insisting upon the importance of laceration as a cause, we do not entirely exclude some cases due to the pressure of forceps, but they are very few. To Sir Victor Horsley, in 1884, is due the credit of experimentally pointing out the tearing element in these cases. He showed that the usual cause is traction on the nerve cords.

The ætiological factors which have been advocated are:—

1. Backward pressure on the nerves by the clavicle.
   (*a*) On the transverse processes of the vertebræ.
   (*b*) On the first rib.
2. Hyper-extension of the arms in breech cases.
3. Pressure of forceps.
4. Tension on the nerve roots.

Clarke, Taylor, and Prout[1] made 20 dissections upon 10 infants dying within three to ten days after birth, and they showed that—

(*a*) The clavicle is small, and has a smooth, rounded posterior surface; it is so curved as to fit around the neck without localised pressure; it is somewhat flexible, and the ligaments of its articulations, at both ends, are so loose as to allow free play of the bone in any direction.

(*b*) The first rib is small, flat, and very flexible.

(*c*) The nerve roots lie between the scalenus anticus and medius, which combined, form a protecting muscle-cushion.

(*d*) There is a thick layer of fascia and fat behind and below the clavicle.

(*e*) The clavicle lies well below the usual site of lesion in brachial birth palsy (that is, the fifth and sixth nerves); and can be pushed up to the latter with some difficulty only.

(*f*) When the clavicle is pushed directly backward, with the limb at the side; or, when it presses backward during hyper-extension of the arm, the nerves glide outward away from the lines of pressure; and, they are pressed upon so little that they slide up and down behind the clavicle with the greatest freedom when traction is applied to them.

(*g*) In hyper-extension of the limb the clavicle rotates backward and slightly downward; it does not rise to the level of the lesion commonly found in brachial birth palsy. The nerves are not rendered tense by the manipulation.

Therefore pressure made either by the clavicle or first rib

[1] *Amer. Jour. Med. Sci.*, Oct. 1906.

FIGS. 448–453.—Illustrations of Birth Palsy and the Results of Treatment. For these photographs we are indebted to Messrs. Clark, Taylor, and Prout, and to their article describing their cases in the *American Journal of Medical Science*, October 1906.

FIG. 448.

FIG. 449.

FIG. 450.

FIG. 448.—(Case 1) Typical Laceration Brachial Birth Palsy of the right arm.
FIG. 449.—(Case 2) 1. Typical Laceration Brachial Birth Palsy; ordinary position in which the patient held the right arm, before operation.
FIG. 450.—(Case 2) 2. The amount of possible supination of the hand, before operation.

FIG. 451.

FIG. 452.

FIG. 453.

FIG. 451.—(Case 2) 3. Amount of Elevation of Arm possible, before operation.
FIG. 452.—(Case 2) 4. Showing patient's ability to place the hand on the top of the head, eighteen months after operation (compare with Fig. 451).
FIG. 453.—(Case 2) 5. Showing patient's nearly normal ability to elevate the arm eighteen months after operation.

cannot produce the palsy; neither can hyper-extension of the limb, nor the pressure of forceps be factors of moment. If the latter are used, the blades are not usually applied as low as the site of the lesion.

In the dissected specimens these writers found that the only factor which caused damage to the nerve roots was tension; and, if sufficiently great, lesions occurred in the same situations as, and of a like nature to, those found in the seven cases they operated upon. Tension arises from increase in the distance between the head and the shoulder. In normal infants from three to ten days old, traction on the shoulder caused the upper nerves of the plexus to stand out like fiddle-strings, while in any other positions they were relaxed or scarcely palpable. Now, in vertex presentations, tension of the tissues of the neck takes place, when the shoulders are obstructed and the head is pulled upon. It also occurs in breech presentations in the delivery of the after-coming head. In experiments on the cadaver, it was invariably found that the fifth nerve tore first, then the sixth, and so on down the plexus in regular order, if the force used was sufficient. The same thing happens clinically, as the mildest cases show only paralysis of muscles belonging to the fifth root and its anterior primary branch, and progress from that condition to cases involving rupture of the entire plexus.

Experimentally, it is found that the nerves do not give way in a limited transverse section, but they *fray out* over a considerable linear area, just as a rope does when it is overstrained. This accounts for the pathological conditions seen in the cases operated upon, such as the development of hæmatoma, with fibrous tissue and nodules in the nerve cords. The lesion may occur in the upper part of the plexus, either in the fifth and sixth nerve above their junction, or below the junction; or, the roots themselves may be torn away from the cord. In severe cases the whole of the plexus may be torn or frayed out; nevertheless, in any case, the maximum of damage is to the fifth root. The supra-scapular nerve is almost always involved, arising as it does from the distal and outer aspect of the junction of the fifth and sixth roots.

Pathology.—The perineurium gives way and its vessels are ruptured, hæmorrhage therefore occurs into the perineural sheath and infiltrates the bundles of nerve fibres. This is a constant appearance in the milder cases. The surrounding parts are also affected; the fascia is thickened and irregularly adherent to the nerves. In the milder cases, a distinct nodular mass can be felt

FIG. 454.

FIG. 455.

FIG. 456.

FIG. 454.—(Case 2) 6. Showing the amount of supination of the right hand eighteen months after operation.

FIG. 455.—(Case 3) 1. Typical Laceration Brachial Birth Palsy. Ordinary position in which patient held right arm before operation.

FIG. 456.—(Case 3) 2. Amount of supination of the right hand, possible before operation.

FIG. 457.

FIG. 458.

FIG. 459.

FIG. 457.—(Case 3) 4. Showing extent of muscle power in the Biceps and Deltoid before operation.

FIG. 458.—(Case 3) 5. Showing extent of muscle power in the Biceps and Deltoid, nine months after operation (compare with Fig. 456).

FIG. 459.—(Case 3) 6. Showing still greater return of muscle power, ten months after operation (compare with Figs. 456 and 458).

later in the injured nerve. When the fibres are ruptured, the ends are found to be more or less rounded and embedded in the hæmatomatous mass. The authors, quoted above, insist upon the recognition of the importance of rupture of the perineural sheath and the resulting hæmorrhage into its substance and into the nerve bundles.

Symptoms.—Usually the symptoms produced by injury of the plexus are of the upper arm or of the Erb-Duchenne type. In other cases they are of the lower arm or Klumpke type. In the worst cases there is entire paralysis of the plexus, with implication of the sympathetic.

The Erb-Duchenne type is produced either by a lesion of the fifth and sixth anterior primary branches or their junction, or, as Wilfrid Harris and Warren Low pointed out, of the fifth alone. The position of the upper arm in this form of paralysis is this:—The limb hangs closely to the side, the forearm is extremely pronated, and the entire arm is rotated inwards. The muscles affected are the deltoid, spinati, biceps, brachialis anticus and supinator longus, and occasionally the extensor carpi radialis longior. Sensation is, as a rule, but little affected. When the fifth anterior primary branch is slightly affected, it is usually the deltoid muscle that suffers, as the fibres supplying this muscle run on the outer and upper side of the fifth nerve cord, or on the outer side of the conjoined fifth and sixth; the supply to the biceps and other muscles being on the lower and inner side.

If laceration of the nerve-roots has occurred, a traumatic neuritis follows: the infant is peevish and fractious for a considerable period after birth, and handling of the extremity causes pain and irritation. Cases that do not present these signs show more or less spontaneous recovery. When they are present, considerable paralysis will follow, depending on the severity of the lesion.

Erb has demonstrated the existence of a point about 2 cms. outside the sterno-mastoid and the same distance above the clavicle, where, by electrical stimulation, contraction may be induced in all the muscles affected in his type of paralysis. It has been shown by him that the motor fibres of the muscles implicated run in the junction of the anterior divisions of the fifth and sixth nerves.

The degree and extent of the lesion in birth palsy cannot be decided immediately after birth. We must watch the symptoms and make electrical tests under an anæsthetic. In the course of a few months one can often detect by palpation a thickening and

FIG. 460.

FIG. 461.

FIG. 462.

FIG. 460.—(Case 3) 4. Showing great reduction in deformity of the right arm, nine months after operation (compare with Fig. 455).

FIG. 461.—(Case 4) Entire Brachial Lesion of the left arm.

FIG. 462.—(Case 5) 1. Mild degree of Laceration Brachial Birth Palsy of the right arm.

FIG. 463.

FIG. 464.

FIG. 465.

FIG. 466.

FIG. 463.—(Case 6) 1. Mild degree of Laceration Brachial Birth Palsy of the right arm.

FIG. 464.—(Case 6) 2. Shows the attitude maintained, without a moment's intermission, for three weeks after operation. The picture was taken at the end of three weeks.

FIG. 465.—(Case 7) 1. Typical Laceration Brachial Birth Palsy of the right arm.

FIG. 466.—(Case 7) 2. Shows the perfected cast for maintaining the proper post-operative position.

induration of the nerve-roots at Erb's point. It is useful to have at hand a table showing the nerve-supply and root-origins of the muscles of the shoulder, arm, forearm, and hand, and, by his permission, I insert the following list taken from Dr. Purves Stewart's work on *The Diagnosis of Nervous Disease.*

Muscles Moving Scapula and Arm.

Plexus Division.

Muscle.	Immediate nerve-supply.	Root origin.
Trapezius	Spinal accessory and branches from	C. III. and C. IV.
Rhomboidei	Directly from	C. IV. and V.
Levator angulæ scapulæ	Directly from	C. III., IV.
Serratus magnus	Posterior thoracic	C. V., VI.
Deltoid	Circumflex (posterior cord)	C. IV., V.
Supraspinatus and infraspinatus	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 thoracics (outer and inner cords)	C. V. and VI. (clavicular head). C. VII. and VIII. (sternal head).
Teres major	Short sub-scapular (posterior cord)	C. VII.

Muscles Moving Forearm.

Triceps	Musculospiral (posterior cord)	C. VI., VII.
Brachialis anticus	Musculospiral and musculocutaneous (outer and posterior cord)	C. IV., V., VI.
Biceps	Musculocutaneous (outer and posterior cord)	C. V., VI.
Supinator longus	Musculospiral (posterior cord)	C. IV., V., VI.
Supinator brevis	Posterior interosseous (posterior cord)	C. V.
Pronators (teres and quad.)	Median (outer and inner cord)	C. VI., VII.

Muscles Moving the Hand.

Flexors of Wrist.

Flexor carpi uln.	Ulnar (inner cord)	C. VII., VIII.
Flexor carpi rad.	Median (inner and outer cord)	C. VII., VIII.

	Extensors of Wrist.	
Extensor carpi rad. longior Extensor carpi rad. brevior Extensor carpi ulnaris	Musculospiral and its posterior interosseous branch	C. VI., VII.
	Extensors of Fingers.	
Extensor communis digitorum	Musculospiral	C. VI., VII.
Extensor indicis . . .	Musculospiral	C. VI., VII.
Extensor minimi digiti .	Musculospiral	C. VI., VII.
	Flexors of Fingers.	
Flexor sublimis . . .	Median (inner and outer cord)	C. VII., VIII.
Flexor profundus . . .	Median and ulnar (inner, outer, and posterior cord)	C. VII., VIII.
Interossei and inner lumbricales.	Ulnar (inner cord) . .	C. VIII., D. I.
Two outer lumbricales . .	Median (inner and outer cord)	C. VIII., D. I.

The Prognosis depends upon the degree of nerve injury and the treatment. In mild cases, where compression alone or a small amount of laceration occurs, spontaneous recovery may be expected in from three to nine months. When laceration is at all severe, the ultimate result depends upon the amount of cicatricial contraction, and upon how far the conductivity of the nerve-fibres is destroyed.

When symptoms of traumatic neuritis are present from the first, the prognosis is relatively bad. Proper treatment, in so far as it assists recovery of the nerves, prevents contractures of the muscles and ligaments, and obviates deformities, greatly influences the prognosis.

Treatment.—When traumatic neuritis is present, the part should be entirely at rest for three or four months, and care must be taken to keep the extremity in the normal position, so as to prevent contraction of the muscles and ligaments. If no evidence of neuritis is present, massage, passive movements, douches, and electricity are of service.

Operative Treatment.—Opinions differ as to the time when operation should be undertaken; some say three months, some six, and others twelve months. The advantages of waiting lie in the fact that the parts are larger, the lesion has become definitely localised, and the infant bears an operation better.

The Operation.—The child is placed upon the couch with the neck moderately extended, the head rotated to the sound side, and a pillow beneath the shoulder. An incision is made from the posterior margin of the sterno-mastoid, at the junction of its middle and lower thirds, to the union of the middle and outer thirds of the clavicle. A dissection is then carried through the fat-layer to the deep cervical fascia, and the nerve trunks are exposed. These are then carefully palpated, when the damaged portions are felt to be thicker and harder than normal nerves. The extent and distribution of the paralysis, having been determined before operation, gives the clue as to which roots are at fault. Usually, the junction of the fifth and sixth roots is the site of maximum damage. The thickened indurated areas are excised by means of a sharp scalpel, and the nerve-ends brought into apposition by lateral sutures of catgut. Cargile membrane is wrapped about the nerve junction so as to prevent connective tissue ingrowth. The wound is closed and dressed, and the part fixed in plaster of Paris in order to approximate the head to the shoulder (Figs. 464, 466). This position should be maintained for at least three weeks to allow healing of the nerves. Particular attention is given to the suprascapular nerve which, as we have stated, is given off from the site of maximum damage. This nerve should always be sutured with the greatest possible care to the proximal stump since it supplies the external rotators of the shoulder, paralysis of which is the cause of the posterior dislocation, often seen in older children.

When the lesion is more severe and extends downward, the clavicle must be divided if necessary. If the lesion involves the whole plexus, it is better to do a portion of the work on the nerves at a first operation and complete it later; otherwise, the total procedure may be too long and exhausting.

Of seven cases operated on by A. S. Taylor, two died, one from shock and one from diarrhœa. At the time of writing the article, Taylor reported a very great improvement in two cases, the movements of the limb being largely regained.

To return to *injuries of the brachial plexus from other causes*, an interesting form is that arising from a cervical rib or from the development of an exostosis.[1] A cervical rib is more often present in women than in men, and is often bilateral; the symptoms, however, are generally present on the right and seldom on the left side. About 5 to 10 per cent of patients with cervical ribs present nerve-symptoms. Four of the five cases seen by the writer so affected, have all been in early adult life. The ulnar is naturally the first nerve to be involved, and then the flexors of the

[1] Keen, *Am. Journ. of Med. Sci.*, Feb. 1907, page 173. An analysis of previously recorded cases is given.

fingers. The patient complains of sharp pain along the inside of the arm, with numbness of the inner side of the hand and little finger, and sometimes anæsthesia. Occasionally, chilblains develop on the little finger, and, as a rule, the intrinsic muscles of the hand are atrophied. I have also seen herpes on the little finger. The treatment of these cases is simple :—Removal of that portion of the cervical rib which presses upon the lower cord of the plexus (see Vol. I. p. 26).

We have remarked that injuries of the brachial plexus may be divided into supra- and infra-clavicular varieties. We have, in dealing with birth palsy, described cases of the supra-clavicular variety, and we now turn to the *infra-clavicular form*. The most usual cause is dislocation of the head of the humerus. Injury is sometimes due to direct pressure by the head, occasionally to clumsy attempts at reduction with the heel in the axilla, sometimes to fracture of the surgical neck of the humerus or of the scapula, or to combined dislocation and fracture of the upper end of the humerus. Occasionally, the whole plexus may suffer; but more often the inner cord alone, and rarely the outer, is affected.

The symptoms produced by injuries of the plexus in the supra-clavicular form conform broadly to three types: the upper arm or Erb-Duchenne type, the lower arm type of Klumpke, and injuries involving the whole plexus.

The upper arm type may be present from the first, or there may be a residual paralysis, after a primary affection of the whole plexus. According to Sherren, more than 60 per cent of the patients, coming for treatment, present the Erb-Duchenne type. In paralysis of the Klumpke variety, a typical case shows paralysis of all the intrinsic muscles of the hand, and it is claw-like.

In infra-clavicular lesions, the inner cord alone may be affected, or the whole plexus. Very often, as in the supra-clavicular form, an apparently total lesion resolves itself ultimately into a paralysis of one cord. In the Klumpke type, the characteristic eye symptoms are due to the connection of the eighth cervical and the first dorsal nerves with the sympathetic.

An affection *of the whole plexus* is usually due to direct violence to the head or shoulder, less commonly to indirect, and occasionally it results from an attempt to reduce a dislocation of the shoulder. The symptoms produced by total rupture depend entirely on the level of the injury. If it is above the clavicle, sensation is entirely lost below the lesion, with the exception of that part of the shoulder supplied by the descending branches of the cervical plexus, and a small area on the inner side of the arm supplied by the inter-costo humeral nerve. The sympathetic is also affected, and the pupil is contracted. All the muscles of the forearm and hand are paralysed, and the level of the lesion determines whether the spinati, rhomboids, serratus magnus, pectorales and the sympathetic escape, or are involved. When the inner cord is affected, there is loss of movement and sensation in the parts supplied by the ulnar nerve, and, in addition, the intrinsic muscles of the hand, which are innervated by the median, also suffer. Paralysis of the outer cord causes loss of power in the biceps and the coraco-brachialis, and all the muscles supplied by the median nerve, except some of the intrinsic muscles of the hand. Paralysis of the posterior cord results in loss of power in the muscles supplied by the musculo-spiral and circumflex nerves, and loss of sensation in their cutaneous areas.

Prognosis.—Warrington and Jones[1] have shown that spontaneous recovery occurred in 30 to 40 per cent of their cases, and Bruns' figures are very much the same. The prognosis depends upon the nature and the extent of the injury; a complete paralysis of the plexus will require years for recovery, even after an operation. When there has been much tearing of the nerve-fibres, with great infiltration of fibrous tissue or kinking of the nerve-fibres, it is evident that spontaneous recovery is impossible. When the whole plexus is bound down, as in a case of ours, in a firm sheath of fibrous tissue, no amelioration can be expected except by operation, and, even then, recovery must be extremely slow. Generally, recovery from injury of the supra-clavicular part of the plexus is less likely to occur than after infra-clavicular lesions. Finally, much must depend upon the skill and care of the surgeon in diagnosing the extent of the lesion, its situation, and his operative skill.[2]

Diagnosis.—Cerebral lesions should be excluded as the following case of ours demonstrates :—

CASE 27. *Severe Laceration of the Supraclavicular part of the Brachial Plexus and Complete Paralysis of the right arm; Nerve Anastomosis; Partial Recovery.*—E. J. S., aged 25, a sailor, was admitted to Westminster Hospital in January 1906. He was sent to the author by his colleague, Dr. Purves Stewart, with the diagnosis of rupture of the plexus. On August 20, 1905, he was thrown against the bulwarks of a Transatlantic liner. He was picked up, unconscious, and the right

[1] *Lancet*, 1906, vol. ii. page 1644.

[2] In birth palsy about 70 per cent of the cases spontaneously recover (Sherren).

arm was limp and flaccid. When the ship arrived at New York, the patient was still unconscious. He was taken to a hospital there and was trephined over the Rolandic area, under the impression that he was suffering from meningeal hæmorrhage, but the trephining operation was unsuccessful in relieving his symptoms. When the patient recovered consciousness, he noticed that the right supra-clavicular region was much bruised and swollen, and the right arm was powerless.

When he came under the writer's care in January 1906, he had complete flaccid paralysis of the right arm, including the pectorales, but not the serratus magnus nor the trapezius. There was complete anæsthesia of the limb, except over the area supplied by the intercosto-humeral nerve. Faradic excitability was entirely lost.

An operation was performed by me on February 12, 1906, and the whole length of the brachial plexus from the spine to the lower part of the anterior axillary fold was exposed. The supraclavicular portion of the plexus was found to be involved in a dense mass of fibrous tissue, which was dissected away and the cords entirely freed. All the roots were found torn apart and matted together by scar-tissue, which intervened between the proximal and distal segments. This scar-tissue was excised, and the upper and lower segments of the nerve-cords sutured together, *en masse*.

No signs of improvement followed until March 12, 1908, when return of power in the biceps was noted, so that he could flex the fore-arm to the right angle. There was also some recovery in the deltoid, and it responded to faradic stimulation. On March 12, 1909, the biceps and brachialis anticus had completely recovered, so that he had full power of flexion of the forearm, and the deltoid acted, so that he could draw his arm away from the side for about four inches. The biceps, though smaller than that on the opposite side, was of considerable size, and became firm and solid, when in action; and the fibres of the deltoid could be felt to harden, when attempts were made to abduct the arm.

With regard to sensation, it was found on March 12, 1909, to be present all over the skin of the upper arm, down to the elbow; although it was poorly marked on the lower half of the outer side of the upper arm, sensation was present in the following areas:—

(*a*) The cutaneous branches of the circumflex nerve, derived from the fifth and sixth cervical nerves.

(*b*) The upper external cutaneous branch of the musculo-spiral, derived from the sixth and seventh cervical roots.

(*c*) The internal branch of the musculo-spiral, derived from the fifth root.

(*d*) The lesser internal cutaneous nerve, derived from the sixth (?) cervical root.

(*e*) And as we have before mentioned, over the intercosto-humeral nerve, derived from the second dorsal root.

So that the recovery of motor power was on March 12, 1909, limited to the biceps, brachialis anticus, and partially to the deltoid, but the supinator longus did not respond, nor did the muscles below the elbow. Sensation was gradually advancing down the arm.

On May 5, 1911, it was noted that there was good power in the biceps, and that the arm could be abducted almost to the right angle by the deltoid. Common sensation had advanced slightly downward.

Hæmorrhage into the cervical cord gives rise to symptoms very similar to those of rupture of the plexus. In hæmatomyelia, the muscles on the same side of the body below the site of the lesion are more or less spastic, the reflexes are increased, and Babinski's sign is often present. Further, the patient is insensitive to pain, heat, and cold, on the side of the body opposite the lesion, and the cervical sympathetic on the same side is interfered with.

The exact localisation of the plexus-lesion depends upon a careful muscle analysis, particularly of the serratus magnus, the rhomboids, the supra- and infra-spinatus muscles, and observations on the sympathetic.

It is difficult to distinguish between incomplete and complete division of a nerve. Sherren claims to have discovered a method of doing so by electrical reactions, thus: "When division is incomplete, on about the tenth day the muscles do not react to the interrupted current, but react in a characteristic manner to the constant current. In incomplete division, the strength of that current, necessary to call forth the contraction, is less than on the sound side. The contraction so produced is brisk as compared with that seen when R. D. is present, and polar reversal is as a rule absent." When we have paralysis of isolated muscles together with a palpable thickening at one particular point in the plexus, we may suspect incomplete division. Thus: A boy came under our observation with paralysis of the deltoid muscle only. We suspected a pressure lesion of the fifth anterior primary branch, or at the junction of the fifth and sixth. On operating, and testing with sterilised electrodes, we found that stimulation of the outer portion of the junction of the combined fifth and sixth nerve failed to cause a contraction of the deltoid. Therefore a flap was raised from the outer portion of the combined cord below the point, and grafted into the seventh, with partial recovery of the muscle.

Treatment.—Immediately after an injury, the part should be kept at rest and supported, in order to allow absorption of blood and healing to take place. A paralysis, which appears to be complete, will often resolve itself into an incomplete paralysis, affecting one or two nerve cords. So soon as the pain due to traumatic neuritis has passed away, massage, electricity, passive movements, and the application of splints to the limb, in such a way as to prevent deformity, are called for. Careful electrical tests are made, and if the reaction of degeneration is present, generally about fourteen days after the injury, operation is necessary.

In supra-clavicular lesions an incision is made from just below the middle of the posterior border of the sterno mastoid down to the clavicle, avoiding the spinal accessory nerve. A second incision is then made along the clavicle outward for a couple of inches, and the flap so formed is drawn back. Careful dissection of the superficial and deep fascia is necessary, and the nerve-fibres are exposed and palpated; in pressure-paralysis there will be found hardening and thickening at one spot, which indicates the position of the lesion. The nerves should also be tested directly by sterilised electrodes, and the resulting movements noted. In extensive damage of the plexus the whole of it may be found encased in firm cicatrised tissue. Removal of the scar-substance and identification of the nerve-cords require much care.

When the lesions are localised, they are excised, and end to end union effected; or, if the interval be too great, we have a choice of two procedures: either to insert a portion of the radial or internal saphenous nerve, or to insert the affected fibres below the lesion into a neighbouring nerve, the latter proceeding being in my opinion more satisfactory. In all cases it is essential to trace, in the dissection, the supra-scapular nerve, and the nerves to the rhomboids and serratus magnus; the phrenic nerve may be seen, but it should be avoided.

Both in ordinary traumatic rupture of the plexus and in birth palsy it may be necessary to divide the clavicle and expose the whole plexus. This prolongs the operation considerably, and is likely to give rise to considerable shock.

Muscle Transplantation for Traumatic Lesions of the Brachial Plexus

In one case, and before the possibilities of nerve anastomosis were fully grasped, the writer had restored power to the biceps by grafting into it a long and powerful strip taken from the outer head of the triceps, and the patient regained the power of flexion of the elbow. Efforts to replace the deltoid were not so successful (Vol. II. p. 678).

In paralysis of the serratus magnus (scapula alata) the writer devised an operation for replacing it (Vol. II. p. 686).

Injuries to nerves of the lower extremities result in typical deformities, which are similar to those seen as the results of infantile paralysis, and are treated precisely on the same lines by apparatus, tenotomy, tendon- and muscle-grafting, and nerve-anastomosis.

CHAPTER VI

DEFORMITIES OF NEURO- AND MYO-PATHIC ORIGIN

Locomotor Ataxy and Charcot's Disease of the Spine and Joints—Hereditary Ataxy or Friedreich's Disease—Syringomyelia—Deformities due to Multiple Neuritis—Osteopathies and Arthropathies—Spasmodic and Paralytic Wry-Neck—Myopathies—Progressive Muscular Atrophy—Peroneal Type—Pseudo-Hypertrophic Paralysis—Muscular Dystrophies.

Deformities Arising from Degeneration of the Spinal Cord

LOCOMOTOR ATAXY

The symptoms of locomotor ataxy are sufficiently well known not to require extended description, and the most interesting complications from a surgical point of view are the spontaneous fractures of bones and the peculiar joint-lesion, known as Charcot's disease. Fractures may occur in any of the long bones, and the curious feature of these lesions is that they unite readily, with the formation of much callus.

Charcot's disease usually affects the knee. According to Gowers and Taylor[1] the percentage of joints affected is as follows: the knee 45, hip 20, shoulder 11, tarsus 8, elbow 5, and ankle 4 per cent. Mr. J. H. Targett has described two cases of Charcot's disease of the spinal column, giving rise to a very exaggerated form of curvature, and the writer can recall a case of tabes in Westminster Hospital, in which fracture of the spine in the lower dorsal region occurred. Changes in the tarsal articulations and bones cause the foot to become flat, giving rise to the condition designated by Charcot and Féré as "tabetic club foot."

The nature of the changes in the joints is now fairly well known. They sometimes succeed an injury, and often the arthritic structures rapidly become inflamed; swelling and acute disorganisa-

[1] *Discases of the Nervous System*, 3rd ed. vol. i. p. 460.

tion follow; subluxation and dislocation are comparatively common. The articular cartilages are eroded, the bony surfaces rapidly waste and disappear, the ligaments are lax, and the joints become flail-like. Such changes constitute the atrophic form of the disease. In a fair proportion of cases, however, it happens that the ends of the bones become enlarged, the ligaments thicken, and there is great effusion of fluid into the tissues around the joint, so

FIG. 467.—Locomotor Ataxy. Spondylolisthesis and fracture at the lumbo-sacral junction (Krönig).

that it is enormously swollen. This constitutes the hypertrophic variety.

Treatment.—So far as surgical treatment is concerned, immediately the fracture is detected or signs of joint-affection are noticed, the patient should be placed at rest and suitable splints applied. For the arm, malleable iron, and for the lower extremity, the knee-calliper splint is useful. Sometimes the joint-condition subsides, and for a time the functions of the part may be resumed. This is not the usual rule. In all cases of Charcot's disease of the knee, much weakness and disability may be avoided if the splint is applied as soon as possible. And, even when the joint has become disorganised and flail-like, this form of splint enables the patient to stand and perhaps to walk.

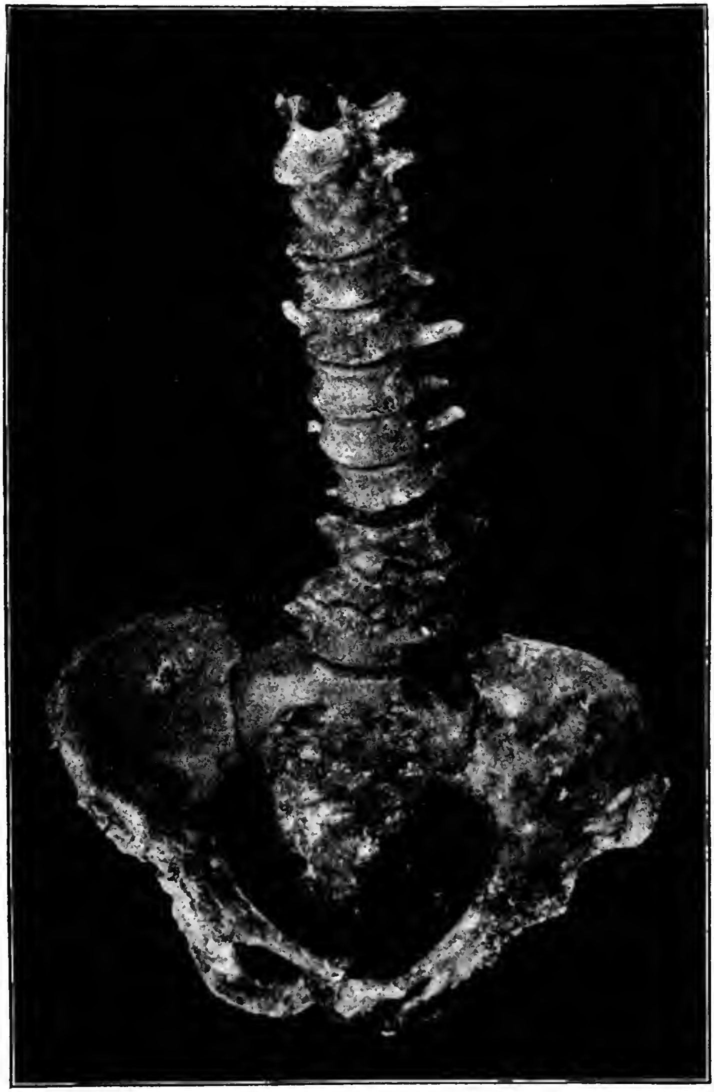

FIG. 468.—Locomotor Ataxy. Fracture of spine between the third and fourth lumbar vertebræ (Abadie).

The treatment of the ataxia itself consists of strengthening the muscles, as suggested by Professor von Leyden,[1] Professor Goldscheider,[2] or by the more recent methods of Fränkel.[3]

Fig. 469.

Fig. 470.

Fig. 469.—Charcot's disease of the right elbow (J. K. Young).
Fig. 470.—Charcot's disease of the left hip (J. K. Young).

Fig. 471.—Charcot's Disease of the knee-joint (J. K. Young).

The systems associated with the names of von Leyden and Goldscheider aim at an increase of muscular power by means of

[1] "Die Behandlung der Tabes," *Berlin. klin. Wochenschr.* Nos. 17, 18, 1892.
[2] *Anleitung zur Übungsbehandlung der Ataxie.* Leipzig, G. Thieme, 1899.
[3] *Bemerkungen zur Übungsbehandlung der Ataxie.* Leipzig, G. Thieme, 1899.

gymnastic exercises aided by apparatus, while that of Frānkel consists of a carefully devised system of graduated exercises, which require no apparatus, and can be practised in the home. The movements are of a simple character, stress being laid on their frequent and careful repetition. No claim is made of any influence on the tabetic condition, but merely on one of its most distressing symptoms—the ataxia. Unquestionably, in many instances much improvement has followed constant efforts in this direction.

FIG. 472.—Charcot's Disease of the left ankle (J. K. Young).

Surgical interference with joints in Charcot's disease is most unsatisfactory and excisions are unpromising. Of eighteen cases of locomotor ataxy in which resection was performed by Ullman,[1] in nine cases the results were unfavourable; of these, two patients died as a direct result of the operation, three required amputation, and in one non-union followed.

HEREDITARY ATAXY OR FRIEDREICH'S ATAXY

Hereditary ataxy or Friedreich's ataxy has the following characteristics:—There is muscular inco-ordination of the arms and legs with loss of knee reflexes, unsteadiness of the neck and

[1] *Deutsche Ärztezeit*, Oct. 1, 1900.

head, blurring of speech and nystagmus. Optic atrophy, lightning

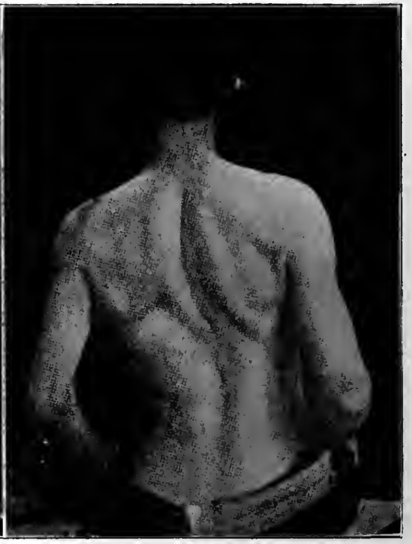

FIG. 473. FIG. 474.

Stereoscopic views of a case of Scoliosis occurring in the course of Friedreich's Ataxy (T. Wardrop Griffith).

pains and visceral crises are, as a rule, absent. The age of the patient at the time of the onset of the disease is a diagnostic point.

The deformities associated with Friedreich's ataxy are lateral curvature of the spine (see Figs. 473, 474), talipes equino-varus (Figs. 475, 476), talipes

FIG. 475.—Talipes Equino-Varus associated with Friedreich's disease; from a patient in Westminster Hospital.

FIG. 476.—The left foot seen from the outer side. The patient is the same as in the preceding figure.

arcuatus and plantaris, and, occasionally, contraction of the knees. The lateral curvature of the spine is due, in the first place, to muscular weakness, and then to the effects of ill-posture. It should be combated by every possible means; however, as a

FIG. 477.—Commencing deformity of the foot in Friedreich's disease. Note the accentuation of the plantar arch (T. Wardrop Griffith).

rule, despite exercises, recumbency, and supports, it increases and becomes permanent. The condition of the foot is very typical. It is one of talipes plantaris combined with equino-varus. The foot is inverted, the heel is raised, the instep is excessively arched, and

FIG. 478.—The same case on plantar stimulation. Note the dorsiflexion of the great toe, dorsal flexion at the other metatarso-phalangeal articulations and the plantar flexion of the interphalangeal joints (T. Wardrop Griffith).

much contraction of the plantar fascia is present. The heads of the metatarsal bones are on a lower level than the heel, the toes are hyperextended at the first interphalangeal joints, and flexed at the second (Figs. 477, 478).

As the prognosis of the disease is so serious, it is certainly not advisable in the majority of cases to interfere surgically; yet, if the amount of inco-ordination is slight, and, if it is evident, that the loss of walking power is due to the abnormal position of the feet, then an attempt should be made to remedy their position, as the patient may obtain relief for a time. Nevertheless, it should be clearly understood that the improvement is often temporary.

SYRINGOMYELIA

Syringomyelia is a condition of the spinal cord in which, owing to cystic degeneration of a gliomatous growth surrounding the neural canal, cavities of varying sizes and shapes are formed in it. The lining of these spaces is gliomatous, and outside is the white substance of the cord, often deficient in amount, and distended by the fluid which accumulates in the cavities. The main features of the disease are loss of sensation, chiefly to pain and temperature, and a muscular atrophy very similar to that which is found in progressive muscular atrophy. The loss of sensation usually affects the arms and upper part of the trunk, and corresponds with the area of muscle wasting, or is a little greater than it. When the condition involves the pyramidal tracts, it gives rise to a form of spastic paralysis. As a result of the atrophy of the muscles of the trunk, lateral curvature of the spine occurs, and generally the convexity is to the right. If the pyramidal tracts of the cord are affected, the lower extremities are spastic. On account of interference with the trophic impulses, thickening of the bones (Pl. XXXIV.) has been met with, and, occasionally joint symptoms, such as in Charcot's disease, supervene. Unfortunately, no treatment of the disease is successful. The spine should be supported so as to control, if possible, the curvature.

Myelitis of the cord, arising from any cause, gives rise to symptoms and deformities closely comparable with those found in infantile and spastic paralysis, to which are added sensory disturbances. Contraction and malposition of the limbs follow; and, if the patient live long enough, they may call for surgical interference.

Deformities Arising From Multiple Neuritis

The usual causes of multiple neuritis are chronic alcoholism and the introduction of lead, arsenic, or other mineral poisons into the

Bones of the Hand from a case of Syringomyelia (Alban Köhler). The patient, aged 39 years, came to the clinic with a swelling of the left forearm, which had existed for three weeks. A fracture had occurred from a fall and, in spite of it, the patient had continued to use the limb at work. The alterations of sensibility to temperature were marked in the hands and feet. In the skiagram (1) the thickening of the pulp of the fingers is especially well marked in the fourth finger, and the last phalanx is hypertrophied, but atrophic in structure. At the distal extremity of the right third metacarpal bone is an osteoma, which may have been caused by an injury. The bones of the left hand (2) are much more atrophic than are those of the right, and they are not so clear in outline. The atrophy is particularly evident at the bases of the first phalanges of the index and little fingers, and in the second phalanx of the third finger.

To face page 772.

body. In addition, multiple neuritis arises from diabetes, gout, rheumatism, syphilis, and is a sequel of septicæmia. It also complicates diphtheria, small-pox, typhus, and enteric fever. According to Gowers and Taylor[1] tuberculous neuritis undoubtedly occurs, but it is "a form regarding which we have still much to learn."

In alcoholism and lead poisoning, the dorsiflexors of the ankles, the extensors of the toes, and the extensors of the wrist and fingers are usually first affected, so that foot- and wrist-drop follow. Subsequently, other muscles may be involved. Reaction of degeneration, loss of superficial and deep reflexes, trophic changes in the skin, hair and nails, anæsthesia and hyperæsthesia either follow or appear simultaneously with the muscular weakness.

Treatment is (*a*) Preventive, (*b*) Remedial.

(*a*) *Preventive.*—As most cases of neuritis are benefited by complete rest in bed, there is a natural tendency, owing to gravity and the weight of the bedclothes, for the feet to point downwards, and secondary contraction of the calf muscles and tendo Achillis follows. The deformity can be anticipated and prevented by the following measures: morning and evening, the feet are passively dorsiflexed, the affected muscles well rubbed, and stimulated by the interrupted current. The feet should be kept by a splint or a tin-shoe at a little less than a right angle with the leg. On account of the weakness of the extensors of the knees and hips, contraction of these joints may occur; and it must be prevented by weight-extension or by a Thomas' hip-splint.

(*b*) *Remedial.*—When contractions have formed, the propriety of dividing the tendons ought to be considered. Nevertheless, operation should not be undertaken too early, for if the extensor muscles recover power, much of the contraction disappears on walking. If, however, deformity is persistent, tenotomy is called for.

The wrist-drop is treated on lines precisely similar to the foot-drop. At the wrist we aim at securing hyper-extension; and, in very severe cases, tenotomy of the flexors of the wrist may be required before hyper-extension can be obtained. The extensor muscles should be well massaged and rubbed; and, it will often be found that, on trial, the patient can lift his fingers from the splint. This marks the beginning of recovery, which progresses until more or less complete power is regained.

[1] *Diseases of the Nervous System*, 3rd edit. vol i. page 147.

Neuropathic Conditions of the Bones and Joints

Lesions of these structures are met with in the course of locomotor ataxy, syringomyelia, Pott's disease, acute myelitis, injury to the peripheral nerves, cerebral hæmorrhage, tumours of the cord, crushing of the cord, and anterior poliomyelitis. The lesions may be considered under the headings of osteopathies, arthropathies, and osteo-arthropathies, and the changes occurring in locomotor ataxia may be considered as typical of these diseases.

Osteopathies.—In locomotor ataxia, spontaneous and painless fractures occur, due to changes in the nutrition of the bone. It is curious that union generally takes place, and with the exudation of much callus. The lower limbs are more frequently fractured than the upper, and in women more often than in men. From the point of view of morbid anatomy the changes in the bone are increase in the size of the medullary canal and decrease in the thickness of the compact tissue, thus indicating gradual absorption of the osseous tissue; and with these changes there is a decrease in the lime salts.

Arthropathies.—These are also known as Charcot's joints. An atrophic and a hypertrophic form are described. The atrophic is met with in the hip and shoulder, and the hypertrophic in the knee and elbow. The characteristic points in these neural arthropathies are their very rapid onset, without pain and fever, the extreme distension of the joint, in a few hours, and the rapid disorganisation which occurs. The changes are not limited to the joints alone, but they extend to the neighbouring tissues. Occasionally the onset is more gradual. As a rule the destructive stage subsides in a few days or weeks. It may leave the joint either hopelessly disorganised or very little damaged, or in intermediate conditions between these extremes. The joints attacked are, in order of frequency, the knee, hip, shoulder, tarsus, elbow, ankle, wrist, jaw, and spine, but the hand usually escapes. These arthropathies bear some resemblance to arthritis deformans, but they differ from the latter in the absence of pain and fever, the very rapid destruction effected, the monarticular distribution, and the fact that there is less tendency to ankylosis, and the joints are usually left flail-like. In some forms of Charcot's joint, no deposits of new bone are found. The pathological changes are in some respects similar to those of arthritis deformans. The articular surfaces are greatly altered. In the atrophic variety, the bone-ends almost or entirely disappear, and the semblance of a joint is lost. In the hypertrophic form, the articular cartilage disappears, leaving bare porous cancellous bone, at the margins of which there are a few, sometimes large, bony outgrowths. The ligaments and capsule of the joint are relaxed, and distended with a clear fluid. The synovial membrane is thickened, and in some cases partially destroyed. So too are the internal ligaments.

Arthropathy, associated with infantile paralysis, was described by Dr. (now Sir Thomas) Barlow in 1883. Dr. J. A. Coutts[1] suggested its identity with Charcot's disease, and described three cases. In all, the ankle was affected, and the effusion was very persistent. The arthropathy is usually limited to one joint, and its onset is synchronous with the poliomyelitis, or it appears some weeks afterwards.

Osteo-arthropathies.—Examples of this type are seen in the spine and the feet. The spinal lesions have already been alluded to in Vol. I. p. 481, and kyphosis, scoliosis, and spontaneous fracture have been discussed. The foot may be flat, or it may be deviated outward or inward, and in some cases the arch of the foot is raised. Lunn[2] described a case, in which there was great deformity of the plantar arch, the tarsal bones in front of the astragalus standing out prominently on the dorsum of the foot. Targett[3] thinks no form of dislocation can be considered as peculiar to the tabetic foot. A perforating ulcer is frequently met with at the same time.

Arthropathies are met with in syringomyelia. The large joints of the upper extremity are those usually affected. Howard Marsh and Gordon Watson state[4] that, "its distribution is as follows: shoulder 32; elbow 24; wrist 18; hip 4; knee 7; tarsus 7; and other joints 8; that is, 74 per cent in the upper and 18 per cent in the lower extremity." This is a striking contrast with the incidence of Charcot's disease.

It appears there are two varieties of arthritis—the hypertrophic and the atrophic. In the hypertrophic form the changes are in the cartilage and bone, and are very similar to those described as occurring in osteo-arthritis, or arthritis deformans of the hypertrophic type. The capsule of the joint in this form is dilated and shows deposits of bony or calcareous material, whilst on its inner surface pedunculated outgrowths of the synovial membrane occur; these may become detached. Periostitis takes place in the

[1] *Med. Times and Gazette*, 1887. [2] *Trans. of Clin. Soc.* vol. xx.

[3] *Pathol. Soc. Trans.* vol. xlviii., 1897, and *Clin. Soc. Trans.* vol. xx.

[4] *Diseases of the Joints and Spine*, 3rd edit., 1910, p. 213.

diaphysis; and the tendons, ligaments, and fasciæ near the joint may become ossified. Spontaneous fractures are not uncommon. The atrophic variety is very similar in its appearances to the atrophic type of arthritis deformans. It is characterised by rarefaction of the cancellous tissues and rapid destruction of the ends of the bones.

The onset of the disease is very similar to that seen in Charcot's affection of the joints. One characteristic is the absence of pain, of redness, and of heat, and the joint suddenly becomes distended by fluid. From a diagnostic point of view the incidence of syringomyelia may be distinguished from Charcot's disease by the sensory, motor, and trophic symptoms peculiar to nerve lesion and by its greater incidence in the upper extremity.

It remains to be mentioned that osteo-arthropathies have been described by Heiberg as occurring in leprosy,[1] whilst in general paralysis of the insane also, the bones become brittle and easily broken.

The question of treatment is difficult in these cases, yet a good deal of comfort can be given to the patient by protecting and supporting the joint, and enabling him to get about with suitable apparatus. Operative measures are not advisable as a rule, although excision of joints has been successfully carried out.

SPASMODIC WRY-NECK

Description.—Spasmodic wry-neck is an involuntary deviation of the head due to spasm of certain muscles. For a full description of the condition, special works on "Diseases of the Nervous System" must be consulted. The subject is treated here and not under wry-neck in general, because the weight of evidence points to its being a neurosis either central or peripheral, and most probably both.

It is met with in females more frequently than in males, and comes on in middle life. The character of the spasm may be tonic or clonic, or both forms may be met with in the same case. It is assumed that the lesion is a central one, affecting either the cortex cerebri, the spinal centres, or possibly the cerebellum; but so far, no lesion, sufficiently gross, has been found to demonstrate the cause of the affection. Sir Victor Horsley has stated to the writer, in the course of conversation, that persons so affected are prematurely aged,

[1] *Leprosy in its Clinical and Pathological Aspects*, by Hansen and Looft, translated by Norman Walker.

they have hard arteries, and arterio-sclerosis of the cerebral arteries has been found *post-mortem.* This is not, however, the experience of other observers.

The condition is somewhat allied to habit spasm, such as writers' cramp. From a diagnostic point of view, the greatest care must be taken to exclude cases of hysterical and neurasthenic origin.[1] In spasmodic torticollis it is interesting to remark that the affection sometimes comes on after a distinct shock to the nervous system, and at other times after a blow on the head. As striking examples, the author refers to the case of a lady, who was engaged and her *fiancé* died suddenly, and to a second lady, who lost her property in the Australian bank failures; to a gentleman, who, while hunting, was pitched on his head, and ever afterwards felt a crick in his neck, which he said compelled him to twist his head about; and to another gentleman who fell downstairs, and struck the back of his head.

Symptoms.—The symptoms appear in the following order: first, spasm; secondly, pain. The spasm is gradual in its onset and intermittent in character, at one time greater and at another less; in most cases, gradually increasing. In rare instances, however, it disappears spontaneously, perhaps after various forms of treatment have been tried and given up as hopeless. This element of uncertainty in the prognosis should be remembered in attempting to estimate the curative value of any given method of treatment. The spasm may remit at times, or even cease, only to reappear with increased force, weeks or months later. It is greater when the patient is walking or excited, and ceases during rest. The pain is usually dull and aching; when the spasm is most marked it is shooting or cramp-like. The muscles, which are affected, neither waste nor show signs of degeneration,—in fact, they are if anything hypertrophied.

When the malady is fully established, the patient's condition is pitiable. The extreme contortions he feels bound to make, and the pain and spasm accompanying them, are such as to render life absolutely miserable. One sad feature of the cases is insomnia. The moment the neck and head are placed on the pillow, the mere contact suffices to evoke the spasm; and in one case, the patient

[1] This may be extremely difficult (Risien Russell, *Trans. of the Brit. Orthop. Society*, vol. iii. p. 10), because anæsthetic and hyperæsthetic areas, exaggerated reflexes, nervous irritability, and insomnia exist; whilst the age, sex and history of nervous troubles, often protean in extent, are suggestive.

could only obtain rest at night, when his wife held his head. In some instances deglutition and speech are interfered with, and the patient often has difficulty in feeding, on account of the jerking movements of the head.

The position of the head varies according to the muscles affected. Their physiological action and of those in combination must be fully grasped, in order to identify the affected structures. In the more superficial muscles, a distinct hardening can be felt at the time of the spasm. The movements can be evoked by weak electrical stimuli, and then the affected muscles overpower the others. Briefly put, the normal actions of the muscles, implicated in the various forms of torticollis, are as follows :—

The sterno-mastoid inclines the head to the shoulder, rotates the face to the opposite side, draws the chin forward and slightly elevates it.

The trapezius (or rather the cervical portion of it) rotates the head to the opposite side, draws it backward, and inclines it strongly to the shoulder.

The splenius inclines the head and slightly rotates the face to the opposite shoulder.

The trapezii and splenii, acting together on both sides, carry the head backward.

The complexus and part of trachelo-mastoid extend the head and rotate it to the opposite side.

The scaleni flex the head antero-posteriorly and laterally.

The combinations met with are :—

1. *The sterno-mastoid and trapezius* of one side, if implicated, cause great inclination of the head to the shoulder of the same side, and some rotation to the opposite side.

2. *The sterno-mastoid of one side and splenius of the opposite side* cause extreme rotation of the head.

3. *Both splenii,* acting together, cause strong retraction of the head—retrocollic spasm.

4. *The sterno-mastoid, trapezius, upper part of trachelo-mastoid and complexus,* acting together, turn the head to the opposite side.

5. *The scaleni, splenius, levator anguli scapuli and platysma,* if acting together, draw the head to the shoulder.

Since, as we shall see, surgical treatment consists either of division of the affected muscles, or—more effectively—of paralysing them by excision of the nerves supplying them, the character of the spasm and the identity of the affected muscles involved must be accurately defined. In some cases, the area varies from time to time, so that prolonged observation is needed before an operation is undertaken. Sometimes, one muscle only is affected, and then in nearly all cases it is the sterno-mastoid, so that inclination of the head is a prominent feature. The right sterno-mastoid is more often affected than the left. The group of head-rotating muscles on the opposite side may also take part in intensifying the deformity.[1] In other cases, the sterno-mastoid, the upper part of the trapezius, and the deeper neck muscles on the same side are affected. In each case the lateral inclination of the head is very marked and rotation less so. More rarely, the head is bent backwards, and the face turned upwards, but there is no rotation. Sir Wm. Gowers states that in one case, which he had seen, the head was retroflexed, the face was horizontal and looked directly upwards. In this form the spasm is bilateral, and the posterior neck muscles, particularly the splenii, were associated, in contraction, with the sterno-mastoids.

In a case of retrocollic spasm which came under the author's notice, the onset was quite sudden, and so severe was it that the patient nearly choked. She became blue in the face, and if the head had not been forcibly pulled forwards, it is probable that she would have been asphyxiated. She told the author that she had been nearly dead on two previous occasions from this cause, but fortunately friends came to her help, and relieved her by pulling the head forwards.

Horsley[2] describes a variety of the affection in which the neck is flexed, the chin bent forwards on the sternum, and the spasm is frequently clonic. From the nodding movement thus produced, this type is called "nutans." The position is probably due to involvement of the straight muscles on the front of the spine, *e.g.* the longus colli on both sides. This form, at all events with tonic spasm, is rare. The author had one such case under his care in 1908, at Westminster Hospital. Section of both sterno-mastoid muscles was done, but without relief to the patient. Shaffer[3] says that he saw a case with contraction of both sterno-mastoid

[1] "If the neck is examined during the spasm, it is very striking to witness the contraction, say of the left sterno-mastoid, and then of the right splenius, complexus, and trachelo-mastoid. When spasm occurs a thick, hard mass forms under the fingers at and just below the sub-occipital triangle" (Sir Victor Horsley, *Clin. Jour.*, 30th June 1897). [2] *Ibid.*

[3] *Trans. of the Amer. Orth. Assoc.* vol. x., 1897, p. 113.

muscles, producing a forward position of the head, very much like that in Pott's disease.

Apart from the types mentioned, cases are seen, in which at the height of the spasm, contraction of the muscles of the face and of the abductors of the arm takes place; and, to complicate matters still further, the affected arm is sometimes on the same side as the spastic sterno-mastoid, and sometimes on the opposite. Too much stress must not be laid on the idea that the groups of muscles affected are necessarily those which normally act synergically.

The **diagnosis** of the affection is not difficult, the only sources of error being cervical caries and hysteria. The points of distinction have already been indicated under their appropriate headings. The real difficulty lies in ascertaining accurately which muscles are involved.

Prognosis.—Once the disease has become fully established, the prognosis, without surgical treatment, is not hopeful. The good effects of operative interference are as a rule most marked; and patients should be counselled to undergo excision of portions of the nerves, if other forms of treatment fail. It is true that very occasionally instances are met with in which the spasm spontaneously ceases after various remedies have been tried and failed. Too often, however, the condition is so distressing that any means of relief is gladly accepted.

Treatment.—Since the causal lesion in spasmodic torticollis has not yet been defined, and the ætiology and pathology are both uncertain, we are reduced to the treatment of the symptoms. Drugs have been tried, and morphia, bromide of potassium, Indian hemp, atropin, gelsemium, and arsenic have all been advocated and found to be failures. There is no doubt that morphia controls the cramping pain of the spasms, and the contractions are somewhat diminished. The risk, however, of acquiring the morphia habit is a heavy price to pay for partial relief. Electricity, in the forms of galvanism to the affected muscles and faradic stimulation of their opponents, has been found to be useless, and is often harmful, as it excites the spasm. Some patients state that they have been benefited by the high-tension current.

Hypnotic suggestion has been advocated in functional cases, but is of little service in examples of the ordinary type. Some cases have been cured by carefully systematised exercises.

Surgical Treatment.—Early cases are partially relieved by appliances, giving some support to the occiput, or to the occiput and chin. But, in well-marked cases the contact of supports with the back of the head provokes or increases the spasm, and therefore they are worse than useless.

Operative Treatment.—Operative treatment is called for:—(1) When treatment by drugs, galvanism, exercises and supports has failed; (2) When the spasm is increasing and spreading; (3) When it is such as to prevent the patient from attending to his business, or is causing insomnia; (4) When there is difficulty in deglutition and respiration; (5) When the patient has become mentally depressed.

The various forms of operations practised are:—Myotomy, which is useless; stretching, division, resection or ligature of the spinal accessory nerve, and resection of the posterior division of the cervical nerves. As to the value of operative treatment great differences of opinion exist, chiefly owing to the fact that the spasm is not definitely nor constantly localised, and may even be transferred from one side to the other. Statistics are of little value, unless the after-course of the cases has been watched for years. In spite of opinions adverse to operation, the condition is of such a distressing character that surgeons have been encouraged to deal with it by measures of a radical nature.

Kocher of Berne has practised most extensive myotomies, but we are not disposed, from our own experience, to advocate this procedure. Stretching or ligature of the spinal accessory nerve gives very temporary results. Excision of a piece of it affords some relief, when one sterno-mastoid alone is affected, but is frequently followed by relapses. They may be partly explained by the fact, demonstrated by Risien Russell, that, after division of the spinal accessory, contraction of the sterno-mastoid occurs, on stimulating the first and second cervical nerves.

The spinal accessory nerve may be resected, preferably at the anterior border of the sterno-mastoid, because there it forms a single nerve-trunk, and cannot be confused with other nerves. The steps of the operation are as follows:—

An incision two inches in length is made along the anterior border of the muscle, with its centre opposite the angle of the jaw. The edge of the muscle is then defined, and if the external jugular vein is in the way it is tied and divided. The muscle-sheath is opened, and the anterior edge lifted outwards. Horsley advises no further dissection; and he determines the identity of the nerve by unipolar excitation, the other electrode being applied to another part of the body. A weak faradic current is used. Richardson[1] says that, "if the finger-nail be passed sharply along the wound, a muscular contraction is caused, when the nerve is touched." If these measures do not suffice to discover the nerve, and the operation is often far from easy, the sterno-mastoid is drawn backwards, and the posterior belly of the digastric muscle, the occipital artery, and the internal jugular vein, are defined. The nerve will then be found running vertically, and enters the muscle an inch below the tip of the mastoid process. About half an inch should be excised. The result is of course paralysis and atrophy of the sterno-mastoid and part of the trapezius.

Exsection of the Posterior Primary Branches of the Cervical Plexus.—If the character and severity of the spasm call for it, and if resection of the spinal accessory alone has proved insufficient, the nerve-supply of the other implicated muscles must be attacked, namely, the posterior primary branches of the first four cervical nerves. This operation appears to have been devised and carried out for the first time by my friend, the late Dr. Gardiner of Melbourne, and to have been performed independently, shortly afterwards, by Dr. Keen of Philadelphia in 1889. The operation has been repeated many times since, often with gratifying results.

In order to reach the nerves, according to Horsley, "the incision is made from the occipital protuberance, upwards along the superior curved line, and then downwards along the back of the neck until the level of the sixth cervical vertebra is reached. It is carried freely through the trapezius, splenius, and complexus down to the laminæ, in a line practically joining the articular processes. The posterior primary branches of the first four cervical nerves are then located and wholly removed. They are readily found, as follows:—The first, or suboccipital, comes out through the sub-occipital triangle, together with the plexus of veins. The vertebral artery is buried with these veins in a mass of fibrous tissue, and gives branches to the muscles bordering the triangle. It is essential to remove accurately the whole of the nerve; and, as the oozing is considerable, it is best to dissect the fascia at once from the muscles forming the triangular spaces, and remove *en bloc* the contents of the triangle and the deep veins. There is free bleeding, which is stopped with pressure forceps in the usual way. Finally, the space is explored with an electrode to ensure that the nerve and its branches have been completely removed. The posterior branch of

[1] Quoted by Royal Whitman, *Orthopedic Surgery*, 3rd ed. p. 643.

the second cervical nerve, owing to its large size, will have been seen in the early stage of the operation. It is simply followed down to the dorsal surface and the intervertebral foramen, and completely removed. The third and fourth will be found most easily, just crossing the lower border of the articular processes, by testing with the current, and can then be wholly removed."

Hitherto the nerves removed have been either on the side opposite the affected sterno-mastoid, or else the removal has been bilateral (Gardiner). More frequently, the spinal accessory and posterior primary branches on the same side need removal, that is, in the class of cases in which lateral inclination is marked, and in those instances where Kocher deems it advisable to divide the posterior muscles on the same side as the affected sterno-mastoid.

FIG. 479.—Reflex Torticollis associated with a cicatrix after removal of tuberculous glands; from a case, under the author's care in Westminster Hospital.

The author suggests that the operation for exsection of the nerves is made easier by the following modifications:—The skin incisions are, one from the occipital protuberance along the superior curved line to the mastoid process, and a second from the occipital protuberance in the mid-line of the neck to the spinous process of the sixth cervical vertebra. The flap is dissected back and the muscles are exposed. The trapezius is cut across horizontally in the middle of the wound, and its ends turned upwards and downwards, likewise the splenius. As it is difficult to define the outer border of the complexus, it is much easier to detach this muscle from its insertion into the spinous processes, and turn it completely outwards. This is the key to the main step of the operation, viz. the identification of the important structures below. The nerves can be quickly found, and are cleaned by careful dissection, and verified by the use of a sterilised electrode.

The paralysis which follows exsection of the spinal accessory and the upper four posterior cervical nerves is of little moment; considerable advantage, however, accrues from dividing the neurectomies in two stages. The resection of the spinal accessory nerve should precede by a considerable interval the intricate operation on the deep cervical nerves, because the first-named operation has been known to be successful, even in cases where movements occurred in muscles not supplied by the spinal accessory nerve. As the trapezius is paralysed and wasted, after division of the spinal accessory nerve, time and opportunity are given for more complete study of the muscles involved in the spasm. In this way unnecessary operations, with their risks and resulting scars, may be avoided.

To sum up the treatment of spasmodic torticollis. All hysterical cases must be carefully eliminated and treated on appropriate lines. Slight examples of the true variety may be helped by massage, supports, drugs, exercises, and perhaps some form of electricity. As to the others, when medical treatment fails and the condition is distressing, resection of the spinal accessory nerve should be performed. If this is insufficient, the posterior cervical nerves involved in the spasm must be excised. If this fails, myotomy, according to Kocher's method, may be considered.

Bibliography

For a *résumé* of the literature on "Spasmodic Wry-Neck" up to 1891, a brochure by Noble Smith may be consulted: "Spasmodic Wry-Neck," Smith, Elder and Co. Since then some of the papers which have appeared are :—

Petit. Rev. d'orth., July 1891. An analysis of 26 cases operated on by him. Excision of a portion of the spinal accessory was followed by success in 13, much improvement in 7, slight improvement in 2, temporary benefit in 3, and one died of phlegmonous erysipelas.

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Other conditions in which the symptoms of wry-neck, except clonic spasm, may be met with, are :—

1. Acute Rheumatic Myositis.—This is the ordinary stiff neck, and should be treated by warmth, massage, and the application of linimentum belladonnæ cum chloroformo. As a rule it disappears in a few days. It may be permanent, and may then be the precursor of myositis ossificans, and occasionally of spasmodic wry-neck.

2. Cicatricial contraction after operation.

3. Pott's disease.

4. The so-called reflex form, due to cervical adenitis, painful inflammatory conditions, such as boils and carbuncles, and irritation from ear-disease.

5. Cervical scoliosis.

6. Astigmatism and unequal vision.

7. Injury to the head and neck, and unilateral dislocation of the cervical vertebræ.

8. Neuralgia.

9. Infantile paralysis (paralytic wry-neck). The paralysis must be most extensive to produce such an effect. Sir William Gowers points out that very little muscular effort is required to keep the face pointing forwards.

Deformities due to Muscular Dystrophies and Myopathies

Certain forms of paralysis are due to muscular and not to nervous disease. They appear as a rule in early life and are named muscular dystrophies. The muscles are affected primarily by a progressive atrophy, so that, in the end, even the largest may be reduced to a band of connective tissue. In some forms, called pseudo-hypertrophic, fat is deposited. The most complete writer on this subject is Erb.[1] At first he distinguished infantile from adult cases, but there is no essential difference. Pseudo-hypertrophic paralysis is not a distinct entity, as some muscles may be fatty, others simply wasted.

The classification is based on the distribution of the paralysis; thus there are—

1. The Duchenne or pseudo-hypertrophic type.

2. The Erb type, chiefly affecting the shoulder-blades and arms.

3. The Landouzy-Déjerine, commencing in the face and arms.

4. The Charcot-Marie-Tooth, beginning in the legs, forearms,

[1] *Deut. Zeitschr. f. Nervenheilk.* 1-13 and 173.

and back. In this form there are lesions in the peripheral nerves as well as in the muscles.

There are few essential differences, with the exception of the deposit of fat, in these types.

Ætiology.—The affections are often hereditary, and it is presumed that there is an inherent inability of certain muscles to survive the wear and tear of life in some individuals, or to put this statement in other words, the life-period of some of the muscles may be less than that of the entire body. There is, in fact, a congenitally deficient power of evolution. As a rule the process is one of simple muscular atrophy. The pseudo-hypertrophic forms are explained by the deposit of fat in the affected muscles.

Pseudo-Hypertrophic Muscular Paralysis (Duchenne Type)

The disease is characterised by wasting and loss of power of certain muscles, preceded in some instances by excessive overgrowth of the affected muscles, in others by atrophy. It is a disease of childhood, affecting males more than females, and is peculiar in that it often affects several members of a family. The disease is transmitted by women, who are not themselves affected.

Symptoms.—The attention is first called to the patient by loss of power, a tendency to fall, and inability to rise again with ease. Then, it is noticed that some of the muscles are rapidly increasing in size, especially those of the calf, extensors of the knee, the glutei and infra-spinati; and this enlargement, with increasing weakness, leads the parents to seek advice for the child. At the same time the lower part of the pectoralis major and the teres minor waste rapidly. The mode of progression is of a peculiar waddling nature, and is very similar to that seen in double congenital dislocation of the hip, so that confusion has frequently arisen.

As a very late result of the shortening and contraction of the muscles, various deformities occur. The knee- and elbow-joints remain flexed, partly owing to the habitual position of the joints, and partly to the retention of some power in the flexors. Contraction of the calf muscles causes equino-varus, and the patient is able to walk less and less. As a result of the shortening and contraction of the calf muscles, the plantar-flexion of the foot may be so great that subluxation of the ankle-joint occurs. The weakness of the extensors of the hips is responsible for lordosis of the spine. As the paralysis progresses, and the spinal muscles become more involved, the lordosis is replaced by kyphosis and subsequently lateral curvature supervenes.

The prognosis is admittedly grave, and a very large number of the children affected do not attain adult life. Generally, the power of standing is lost between the age of ten and fourteen years, in consequence of the weakness and contraction of the calf-muscles. When the patient ceases to walk, the muscular disease at once makes more rapid progress.

Treatment.—There is no doubt that the progress of the disease may be retarded by properly planned exercises, and they do more to improve the condition than rubbing and massage, although the latter measures are of considerable benefit. If it is clear that the contraction of the calf muscles is such as to cause greater interruption to walking than is due to mere weakness, section of the tendo Achillis is undoubtedly advisable. If the patient survive long enough and contraction recurs, a second division is justifiable. For the curvature of the spine, supports are necessary, rubbing and massage being used in combination.

The Erb Type

This form begins as a rule between the ages of twelve and sixteen years. It affects the pectorales, trapezii, rhomboidei, and deltoids, and they are often hypertrophied and at the same time weakened. The biceps and triceps are atrophied. The shoulders are thrown forward and the scapulæ protrude. Later, spinal deformities arise, as in the pseudo-hypertrophic form, and in the feet, talipes equinus and equino-varus appear.

The Landouzy-Déjerine Type

In this affection the atrophy commences in the muscles of the face, and particularly in the orbicularis oris, the risorii, and the levator menti, so that the lips are weak and everted and the mouth is open (tapir mouth). Gradually the atrophy spreads, and the termination of the disease is similar to that in the preceding types.

The Peroneal Type of Muscular Atrophy (Charcot-Marie-Tooth Disease)

In 1886 Dr. Howard Tooth[1] drew attention to a form of muscular atrophy at first appearing in the peronei muscles, in the

[1] Cam. Univ. Thesis, 1886, and *St. Barth.'s Hosp. Reports*, vol. xxv.

extensor proprius pollicis or in the extensor communis digitorum. While the cases seem to be of the nature of a myopathy, yet it is doubtful if it is a pure muscular dystrophy. There is neuritis and probably a cord affection too. Charcot and Marie,[1] Hoffman,[2] Bernhardt in 1893,[3] Sainton in 1889,[4] Warrington and Jones,[5] and Gowers and Taylor[6] have written on the subject.

Males suffer about twice as frequently as females. It usually begins in early childhood, and very seldom after twenty years of age. It is occasionally hereditary, and still more frequently collaterals suffer, brothers and sisters being affected. Other muscles besides those mentioned are involved, especially the calf muscles, and then those of the thigh, particularly the vastus internus. The unequal affection of the muscles of the leg often causes club-foot. Later, the upper extremities are invaded, particularly the thenar, the hypothenar, and interossei muscles. Then the disease extends to the forearms, but the supinator longus escapes. As the muscles of the hand waste, that member becomes claw-like; and Gowers and Taylor insist on the association of club-foot and claw-hand, so unusual in early life, as very significant and almost distinctive. Cutaneous sensibility is stated to be impaired or lost, especially over the region in which the atrophy is greatest, or upon the soles of the foot, but this is very doubtful. Pain is sometimes present, particularly in the muscles of the thighs, and reflex-action is lessened or is lost in the affected regions.

The electrical reactions are peculiar and of much diagnostic value. A true reaction of degeneration in the atrophied muscles, or an entire absence of excitation to either the induced or constant current may be present. Even those muscles which are not atrophied and possess the full amount of power can only be stimulated with the greatest difficulty. Bernhardt and Hoffman record cases in which even the facial muscles did not react to electrical excitation, when either the nerve itself or the individual muscles were stimulated.

Ætiology.—Isolated cases have been recorded but are rare. There is either an hereditary history or several members of the family are affected. In Herringham's cases,[7] the hereditary influence

[1] *Revue de médecin*, 1886.
[2] *Archiv f. Psychologie u. Nervenheilkunde*, 1891, p. 95.
[3] Virchow's *Archiv*, Bd. 133, p. 287.
[4] *Nouvelle Iconographie de la Salpêtrière*, 1889, pp. 216 and 317.
[5] *Lancet*, Dec. 1901.
[6] *Diseases of the Nervous System*, 3rd edit. vol. i. p. 593.
[7] *Brain*, 1888, p. 230.

could be traced through five generations and involved 26 individuals, the males alone being affected. In the majority of cases nothing in the nature of an exciting cause can be ascertained. In others some form of toxæmia has preceded the wasting.

Pathology.—Changes have been described both in the spinal cord and in the muscles. Hoffman considers that this type of the disease is progressive neuro-muscular atrophy, as it is a general affection of the neuron. The following changes have been described: fatty and degenerative changes of the muscles, great atrophy of the peripheral nerve-fibres, an increase of connective tissue between the fibres in the anterior cornua, the large grey cells being smaller than normal, having lost their processes. The cells in the posterior cornua have been found to be diminished in number and atrophied.

Deformities.—The feet show the greatest departure from the normal; they are pointed and somewhat inverted, and held rigidly in the position of equino-varus. Voluntary movements of the toes are often limited, and very frequently a considerable degree of pes cavus appears. As the disease is very slow in its progress, it is essential that the patient should be enabled to get about, and therefore it is recommended that section of the plantar fascia and of the extensors of the toes and tibialis posticus should be made. At a later stage the tendo Achillis may be divided, if contracted. In fact, the surgical treatment is precisely similar to that of talipes equino-varus. Some patients have made excellent recoveries from the deformity, and have been enabled to walk long distances. The treatment of the knees presents greater difficulties, and massage and suitably planned exercises are called for. We have spoken of Thomsen's disease (myotonia congenita) in Vol. I. p. 767.

Schüller[1] describes a primary polymyositis occurring in children; its onset is acute and febrile. Cloudy swelling of the muscles is present, and runs into fatty and vitreous degeneration. The affection begins with a painful affection of the muscles of the trunk, face, and neck. Recovery with some atrophy may follow, or death may ensue after weeks or months, owing to implication of the respiratory muscles. The affection is thought to be of infectious or toxæmic origin. Clinically, it has a considerable similarity to the idiopathic forms we have mentioned.

[1] "Polymyositis in Kindesalter," *Jahrb. f. Kinderheilk.*, N.F., Bd. 53, Ergänzungsheft.

CHAPTER VII

HYSTERICAL AND NEUROMIMETIC AFFECTIONS OF THE JOINTS AND BONES

Definition—Types—Ætiology—Symptoms, General and Local—Examination of the Parts—Diagnosis—Hysterical Spine, Hip, Knee, and Ankle—Hysterical Club-Foot—Functional Affections of the Joints of the Upper Extremity—Treatment.

THESE affections are also called "functional," but as there is in many of the cases a substratum of real though slight disease, the word functional is not quite a correct description of this class of disorder.

Hysteria is difficult to define. It is easier to describe it than to say what it is. Paul Sainton [1] says, "A precise definition can scarcely be made, as it is not a disease in the ordinary sense, but rather a state of reaction and hypersensibility. If its manifestations are varied, it is no less true that they are all specially allied to affections of the nervous system. Briefly, hysteria is a neurosis of many and perplexing varieties and of psychic origin, where disorders often simulate organic disease. Many of the symptoms are variable and merely accidental; others are invariable and form the 'stigmata of hysteria.'"

Whitman [2] points out that, so far as the joints and bones are concerned, hysterical and neuromimetic affections may be divided into two classes:

1. Those in which there is no actual disease or weakness.

2. Those in which the symptoms of disease or injury, or of their effects, are exaggerated or prolonged.

The first class is small, the second is large.

Ætiology.—Our space does not permit us to enter fully upon that debatable subject, the origin and causes of hysteria. Heredity, emotional temperament, want of firm home-training,

[1] *Encycl. Med.* vol. v. p. 3. [2] *Orth. Surg.* 3rd ed. p. 637.

ill-health, and chronic disease are elements in its production. Slight sources of peripheral irritation, and the less degrees of trauma are exciting causes, particularly in the joints and spine; so that the symptoms appear to be perpetuated long after the results of the original injury have subsided.

Sex and Age.—The symptoms of hysteria are common in girls about the age of puberty, and in young women. In the latter we often meet with curious mental perversions, and some of them seem to be possessed of an almost diabolical ingenuity in ascertaining the nature of and simulating organic lesions. Women at the menopause often pass a few years of life tinged with neuromimetic symptoms. Boys and men are not exempt. We are familiar with the lad who consciously or unconsciously malingers in order to escape school or something which he wishes to avoid. In men we have striking examples in the so-called "railway spine," or as we have more fully described it, "the neuromimetic" and the "traumatic hysterical spine."

Symptoms.—Hysterical or functionally affected joint-troubles may arise, as we have remarked, without previous injury or disease, or they are more often a functional prolongation of the original trouble. One point is quite clear—that the symptoms are out of all proportion to the objective signs. We observe too that though an injury may have occurred long before, yet if actual disease had existed all the time, changes of a well-marked and easily recognised character would be present in the joint. There is a want of due relation between time and symptoms. The emotional temperament often excites a suspicion of the causative agency in an observer, and we note that "egotism has its keenest life at and about the supposed seat of the affection." Some people appear to "enjoy bad health." Others are "content or almost happy in their afflictions," and yet others are miserable, and have a morbid craving for sympathy. Will-power is deficient in one direction; though in others, patients have strong and even perverse wills, where their interests are concerned. As Paget said, "I cannot," looks like "I will not"; but is "I cannot will."

In examining the joint, we find that the *pain* is in excess of the signs; it is superficial rather than deep, shifts from place to place, does not occur in those places that we find painful in actual disease, and rarely interferes with sleep. Pain may alternate with anæsthesia, which may be of the "stocking" type or take the form of complete hemi-anæsthesia. Movements of the joints, if carefully performed, do not cause excessive pain, and night-startings and night-cries are absent generally, though, if the patient knows of them, they may be simulated.

The temperature of the body is not raised in a manner consistent with the supposed disorder. If pyrexia is present, it is irregular and capricious, and sometimes fictitious. Locally the temperature is lowered, and the part may be blue or dead white.

Rigidity may be present to a marked degree, or the limb may be weak and useless. If rigidity occurs, movements in any and every direction are resisted; and we may feel the limb stiffen when the examination is made. It also varies when the patient's attention is distracted, and it may be irregular in the sense that it is greatest when the passive movements are least and *vice versa.*

Distortions of the limb are not always characteristic, they may or may not follow malpositions of the limb which are typical of disease. Very often, however, it is noticeable that the limb is not in the position which would give the greatest relief to the alleged pain.

Swelling of the joints is as a rule absent,[1] and atrophy of the muscles may be considerable, though often such as can be accounted for by disease. Hysterical œdema, or angio-neurotic œdema is sometimes present.

Diagnosis.—The surgeon should examine the case with an unbiassed mind, and with the object of discovering disease if it really exists. He must, however, beware of being deceived by injuries intentionally inflicted, or of inflammatory conditions artificially produced and craftily perpetuated.[2]

Being cognisant of all the signs of disease and injury he notes the disparity of the subjective symptoms and objective signs; and his suspicions are aroused. He feels that something is wanting to make the clinical picture complete, and absence of signs is of greater weight to him than the presence of symptoms.

Valuable aids to diagnosis are examinations under anæsthetics and by X-ray photographs. If, with these aids, the surgeon is convinced that no disease is present, then he may conclude that the condition is hysterical or neuromimetic.

[1] Some neurologists describe swelling and local sweating as accompanying functional diseases of the joints.

[2] As in a case where a young girl of seventeen simulated hæmophilia of the knee-joint. It was swollen, extensively discoloured, and there were numerous bruises about the thighs. Eventually an ulcer was noticed on the back of the hand, and she was found one day biting it and spitting blood into a porringer.

The Spine

We have discussed "railway" spine and its manifestations in Vol. II. p. 486, and repetition is needless. Similar conditions are described under the names of irritable spine, hysterical spine, spinal irritation, functional affection, and weakness of the spine. The site of hyperæsthesia and pain is over the spinous processes. In many nervous people the spine is—shall we call it normally?—tender to pressure at certain spots, *e.g.* over the spinous process of the sixth cervical vertebra, the seventh dorsal, and the first lumbar. If people are out of health, or become enfeebled from any cause, the sensitive areas extend vertically and coalesce, the patient walks guardedly with a stiff back, and complains greatly of pain there, when attention is directed to the part. If, however, the attention is distracted, and his mind is engaged on some other subject, he moves the back freely.

People with a short leg, especially women, have an irritable and painful condition of the back, which disappears on compensating the shortening, and with improvement of the general health. We have referred (Vol. II. p. 207) to painful conditions of the lumbar spine and sacro-iliac synchondrosis in such people. The difficulty is to exclude early Pott's disease. Nevertheless it will be noted that "the symptoms of stiffness arise more from an apprehension of possible pain in movement than from the unconscious muscular spasm, seen in the stages of early Pott's disease (Bradford and Lovett). It is always well to remember that reflected pains are of much greater value in the diagnosis of Pott's disease than are local pains.

Sprains of the spinal column are often followed by functional symptoms with spasm. We have also seen spasmodic wry-neck, spasmodic lordosis, and the kyphosis of muscular debility.

Hysterical lateral curvature has been described and illustrated in the section on "Scoliosis" (Vol. I. pp. 482-4).

The Hip

It is only the early stages of coxitis which are simulated; and the signs mimicked are lameness, flexion of the joint, lateral deviation of the spine, lordosis, flattening of the hip, adduction with apparent shortening of the limb. The best method of coming to a decision is to examine the other limb first, and to flex it forcibly at the hip. If it be flexed on to the abdomen without raising the suspected limb from the couch then the diagnosis of a functional affection is quite clear. In addition, we carefully weigh the general evidence, as detailed in our account of the symptoms of joint-hysteria in general. In my limited experience of hysterical hips, I have not seen abduction and apparent lengthening simulated. If, however, doubts remain, then we have recourse to an examination with X-rays and under an anæsthetic. It is impossible for the patient to mimic adequately the *signs*, as distinct from the symptoms, of advanced hip-disease.

In one case of functional coxitis which came under my notice, a girl of fourteen years of age presented herself, and there were lameness, adduction, apparent shortening, flexion, and rigidity with complaints of great pain. My suspicions were aroused, and I asked her "if any one else had a disease like it in her street." She replied, "Yes"; and then I told her that "she was shamming." She admitted the impeachment, straightened herself, put the foot flat on the ground, and walked away, with nothing amiss.

The Knee

The affections generally simulated are tuberculous synovitis, and chronic synovitis. There is often a history of injury, months or even years previously, but the apparent disease is not so advanced as would be the case, if actual disease had existed for the period, during which the patient has complained. Nowhere, however, does functional affection present greater difficulties than in a knee-joint, after an injury. Traumatism even of a slight degree may loosen or displace a semilunar cartilage, and it is very difficult to exclude this possibility. The more we know about affections of the knee-joint, the fewer are the diagnoses of functional trouble. Arthritis deformans of an early and slight type is accompanied by puffiness and slight pain, the significance of which may be unduly exaggerated by the patient and lead him or her to concentrate attention upon the joint. In these instances pain is said to be very severe on movement. However, the painful areas are superficial and uncertain, and even anæsthetic spots may be found. There may also be a slight increase in the surface-temperature in functional affections, but as a rule the skin is cold and blue or white. Generally, the knee is flexed ; yet in many cases it can be straightened passively without pain, and during sleep the flexion disappears. It is rare for contracture of the hamstrings to occur. Occasionally the knee is held rigidly extended, a position quite out of keeping with the alleged severity of the pain. Atrophy of muscles, due to disease or tight bandaging, is common, and causes the knee-joint to appear swollen.

The difficulties of diagnosis are considerable, and we must rely upon our knowledge of knee-joint affections, the results of examination under an anæsthetic and by X-rays, and be careful not to overlook a loose body or cartilage in the joint.

The Ankle

After sprains, functional disturbance of this joint is fairly common, and is generally due to over-prolonged treatment by rest and fixation. The patient finds that the early attempts to move the joint cause access of pain, heat, tenderness, and swelling, and he holds the part rigid. It is well to anticipate this possibility, and we frequently tell patients that they will get well "only with and through pain, and often a good deal of it." If they understand that pain is not harmful, and is to be expected, they are content to persevere in moving the joint.

Hysterical Club-Foot

We have met with several examples of this affection, and the types usually seen are equinus or equino-varus, rarely valgus, and not calcaneus or calcaneo-valgus. In diagnosing the case we exclude spastic and infantile paralysis; and the electrical reactions are of great value. In functional club-foot, if the patient's attention is distracted, it is often possible to replace gradually the foot in the normal position by gentle and deft manipulation. Sometimes, however, it has been held so long in the equinus position, that actual shortening of the tendo Achillis has taken place, and section is required. Generally, however, in obstinate cases of hysterical club-foot it is sufficient to place the patient under an anæsthetic, when the spasm relaxes and the foot can be put in a plaster of Paris bandage in its normal position. This proceeding does more to effect a cure than any amount of exhortation and attention.

Hysterical Affections of the Joints of the Upper Extremity

The joints of the arm and forearm are less often affected than are those of the lower limb. Sometimes, after a sprain of the shoulder, stiffness persists; and it is difficult to tell how far it is due to subdeltoid bursitis, bruising of that muscle, neuritis of the circumflex nerve, or to adhesions within the joint. Again, we must rely upon our examinations of the part, our knowledge of the possibilities and effects of movement under an anæsthetic. The same remarks on the effects of fixation and rest, if too prolonged, apply here as at the ankle.

The elbow-joint is rarely the seat of functional affection without the previous existence of some lesion, such as a sprain, a dislocation, a fracture, or incipient arthritis deformans. In those who use the hands much in performing educated movements, such as piano-practice and typewriting, aching of the wrist and weakness are very common, especially as the subjects are often neurotic, anæmic, and overworked. Spasm occurs, and it is difficult to exclude writer's cramp.

In all the affections we have named, the diagnosis can only be made by exclusion, yet we must remember that functional and organic disease may exist in the same joint, and slight though real symptoms may readily be exaggerated.

The *treatment* of neuromimetic and hysterical joints presents great difficulties. The first point is to make a definite diagnosis, and then to act thoroughly and consistently upon it. To temporise is fatal to success. General measures, to improve the bodily health and mental outlook, are essential. Locally, efforts are made to stimulate the circulation and condition of the part by massage, exercises, and electricity. Appliances and supports are to be avoided, because they concentrate the attention too much on one part of the body. If operative measures are required, they are usually of a simple character, such as manipulation of the part under an anæsthetic, and in exceptional instances, tenotomy. Finally, it is advisable not to belittle the symptoms and treat them as imaginary. It is wise to avoid a contradictory attitude; rather, we should endeavour to secure the patient's co-operation and help. Many of them wish to get well, but have not the will to do so.

APPENDICES.

APPENDIX I

ABSTRACT OF FINAL REPORT OF THE ROYAL COMMISSION ON TUBERCULOSIS

It has been proved that the human and bovine types of tubercle bacilli are morphologically indistinguishable, but differ in respect of their cultural characters and their capacity for causing disease in various species of animals. The bovine tubercle bacillus produces fatal tuberculosis in cattle, rabbits, guinea-pigs, chimpanzees, monkeys, goats, and pigs. The human tubercle bacillus produces fatal tuberculosis in guinea-pigs, chimpanzees, and monkeys, that is, many animals are highly susceptible to the effects of either human or bovine tubercle bacillus, and the disease produced in these animals by both types is bacteriologically and anatomically identical.

In the human subject, fatal tuberculosis can undoubtedly be caused by the bovine bacillus, and the disease so induced presents precisely similar clinical histories and post-mortem lesions as after infection by the human bacillus. Man is therefore notably susceptible to the bovine tubercle bacillus.

Repeated attempts to transmute bovine into the human bacillus have failed, although both kinds of bacilli were obtained from one and the same human body. It is possible that the lesions which they produce were each manifestations of the same disease in man and other animals, and human tuberculosis is identical with bovine tuberculosis. Whilst man is thus highly susceptible to both forms of bacilli, cattle, pigs, and fowls are in no way affected by the human type of bacillus, whereas with the exception of fowls they are very susceptible to the bovine type. It seems then that, with the exception of fowls and other birds, mammals and man can be reciprocally infected with tuberculosis, and many cases of fatal tuberculosis in the human subject have been produced by the bacillus known to cause the disease in cattle. Bovine animals, however, are not absolutely immune to the human tubercle bacillus, but it does not produce fatal results in them. In human beings it seems that the bovine type more especially causes the glandular and abdominal forms of the disease, and not pulmonary phthisis, though this particular type has been found in rare instances. It is important to note that the avian tubercle bacillus was not present in any instant in the lesions of tuberculosis in the human being, and the monkey proved to be highly resistant. The great source of infection of bovine tuberculosis is, undoubtedly, milk; and the remedy is obvious. In amplification of the figures on p. 1 of Vol. II. we may quote the following from the final report, pp. 12 and 13:—"In 42 cases of pulmonary tuberculosis, 40 yielded human tubercle bacillus and 2 bovine tubercle bacillus. Three cases of general tuberculosis and 3 cases of tuberculous meningitis all showed human tubercle bacillus, 5 cases of submaxillary glands gave three of human tubercle bacillus, and two a mixture of bovine and human. Nine cases of cervical glands yielded 3 bovine and 6 human tubercle bacillus. In 29 primary cases of abdominal tuberculosis 14 were found to be purely bovine, 13 human, and 2 a mixture. Fourteen cases of joint- and bone-disease showed, in 13 human tubercle bacillus, and in one a mixture of bovine and human. In one case in which the testicles were affected, and another in which the kidney, and a third in which the supra-renal body was affected, the human bacillus was found in all. So that to sum up: of 108 cases 84 yielded human tubercle bacillus, 19 pure bovine tubercle bacillus, and 5 a mixture. It will be noted that no cases of lupus are included in the above, and the disease is not dealt with in this connection.

APPENDIX II

BÉRANECK'S TUBERCULIN AND ITS METHODS OF APPLICATION

As a very considerable measure of success has followed the use of this particular tuberculin it is thought desirable to give a brief notice of it. Professor Béraneck points out that tuberculosis is a microscopic disease and its evolution depends on two factors:—

I. The tubercle bacilli and its biological properties.

II. The state of the defensive mechanism of the organism in which the development of the bacillus is to take place.

The chronic defence of the body against tuberculosis depends on the pathological properties of the toxins produced by the bacillus. Of these the soluble or exotoxins diffuse readily throughout the body; and the others, the endotoxins, adhere to the bacilli and diffuse with great difficulty. The latter enable the bacillus to resist the bacteriolytic action of the body's protective cells, and gradually produce necrosis of the infected tissues. Under the influence of the tuberculous exotoxins, and especially of the tuberculous endotoxins, the body's means of defence are gradually paralysed, and, if timely intervention is not made, the breakdown becomes complete. We must therefore, 1. Check infection by re-inforcing the resistance of the leucocytes; and, 2. Encourage the anti-bodies, which will neutralise the toxins secreted *in vivo* by the tubercle bacillus. Further, the toxins must satisfy the following conditions:—

(1) They must be soluble, so that accurate dosage may be possible.

(2) They must be less toxic with regard to the body's protective cells than are the toxins produced *in vivo* by the tubercle bacilli.

(3) They must be absorbed and digested by the protective cells, so that their resistance to the pathogenic action of the tubercle bacillus may be increased and their bacteriolytic functions stimulated.

Professor Béraneck claims that his tuberculin fulfils these conditions. Further, he says that his tuberculin is not a serum, as it does not contain anti-bodies, and consequently *per se* it does not exert antitoxic action. He has prepared a tuberculin containing both exotoxins and endotoxins. The exotoxins include the soluble toxins, secreted by Koch's bacillus, in a special bouillon made from a glycerinated maceration of veal, not neutralised. The tubercle bacilli, cultivated on this bouillon and separated therefrom by filtration, are next carefully washed in water and immersed in a 1 per cent solution of ortho-phosphoric acid which extracts certain endotoxins. A mixture of equal parts of the culture bouillon filtered and concentrated *in vacuo* (exotoxins), and the bacillary extract obtained after immersion in ortho-phosphoric acid 1 per cent (endotoxins) constitutes Béraneck's tuberculin.

From theoretical considerations the course of treatment by Professor Béraneck's tuberculin must be considered in reference to (*a*) Neutral doses; (*b*) Beneficial or optimal doses; (*c*) Noxious doses. He advises that treatment should commence with neutral doses, and then the amount be increased, until the beneficial or optimal dose is ascertained. By noxious doses is meant those which provoke pyrexia or other reaction. It therefore follows that a course of treatment with Béraneck's tuberculin should not be at any time accompanied by an appreciable reaction. The optimal dose varies with the individual; and it seems that the secret of the administration consists of a careful observation of symptoms and of a carefully graduated dosage. Different solutions have been prepared according to a scale which has been determined by Dr. Philip.[1] The scale ranges from Tbk 1, which equals 1 : 10 Béraneck's tuberculin 1/20, to Tbk 6, which equals 1 : 1,000,000 of Béraneck's tuberculin 1/20. In non-pyretic cases treatment should be commenced with $\frac{1}{10}$th cc. of Tbk 5, and three days should elapse after each injection before the next is made. The initial dose should be repeated a certain number of times so as to ascertain its effect. Should a reaction ensue, the dose must be reduced to $\frac{1}{20}$th cc. of Tbk 5, or even $\frac{1}{10}$th cc. of Tbk 6. If $\frac{1}{10}$th cc. Tbk 5 be well tolerated, the dose may then be increased by not more than $\frac{1}{20}$th cc. of that strain.

[1] *British Journal of Tuberculosis.* London 1907.

In surgical tuberculosis we can reach the foci of disease without much difficulty, and the lesions are therefore adapted for the immediate and local application of the tuberculin, that is by intra-focal injections. Béraneck claims that they are quite safe and of the greatest benefit in intra-articular lesions. Of course the earlier and smaller the lesion is, the better is the result[1]. The intra-focal method is contraindicated in cases of surgical tuberculosis accompanied by pulmonary or renal lesions, because of the thermal or other reaction which they cause. Such cases, however, may be treated by hypodermic injection. It appears that by these methods we may expect 80 per cent of cures.[2] Very elaborate details of the method have recently been issued by Professor Béraneck from the Laboratory of the University of Neufchâtel.

APPENDIX III

(A) NEW APPARATUS FOR THE TREATMENT OF SPINAL TUBERCULOSIS

Mr. H. J. Gauvain, Resident Medical Officer at the Treloar Hospital and College at Alton, Hants, has devised certain apparatus which have been found very useful in the treatment of spinal caries. The spinal board (Fig. 480) is a modification of the one in use at the Maritime Hospital, Berck-sur-Mer.[3] Mr. Gauvain has modified it and describes it thus :—

"The board, as used at Alton, consists of an oblong tray, made of strong but light wood. The length should be from 12″ to 18″ longer than the patient, and the width about 8″ greater than his greatest width. The sides of the board are about the same height as an ordinary Phelps' box, roughly 3″ to 4″, with the exception of the foot-end, which is raised to a height of from 15″ to 18″, and thereby takes away from the patient's feet the weight of the bedclothes and tends to prevent the onset of foot-drop. The bottom of the board is perforated with numerous holes to admit of ample ventilation of the mattress. . . . Across the board is placed a piece of wood at a suitable height, usually 3″ or 4″, and about the same width, which stretches from one side to the other, and is designed to be placed immediately under the most prominent part of the angular curvature. It is fixed by means of two iron pins which serve a double purpose : (1) To retain the cross-piece in position, and (2) to indicate at a glance where the patient's angular curvature is. A firm pillow, if fixed, forms a suitable substitute for the wooden cross-piece. A well

[1] C. F. Roux, *Revue médicale de la Suisse romande* 8 (1906).
[2] W. de Coulon, *Revue médicale de la Suisse romande*, 20th June 1907.
[3] Ménard, *Étude pratique sur le mal de Pott.* Masson et Cie, 1900.

prepared horsehair mattress occupies the tray and on it the patient reclines. At the head- and foot-ends of the board are slits cut for the hands to facilitate transport. At the head-end of the board two pieces of strong elastic webbing, 1″ wide and about 6″ long, are attached; and to these a bridle can be buckled, when head-extension is desired. At the foot-end are two longitudinal slits. Through them the cords of the leg-extension can be passed over suitable pulleys. These pulleys are fixed to two perforated upright pieces of wood attached to the board on each side of

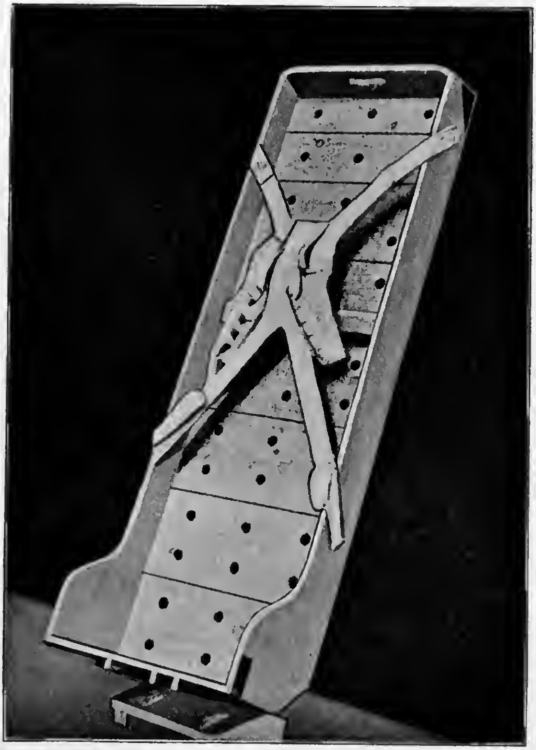

FIG. 480.—The Spinal Board (H. J. Gauvain).

the longitudinal slits, and these are so arranged that between them an upright extension-rod can be inserted if there is much flexion; and if, at the commencement of treatment, the leg cannot be sufficiently extended to allow it to be drawn directly in line with the trunk. . . . The patient is fixed on this board in a very simple and effective manner. A jacket composed of stout jean, fitted accurately to his body and stiffened with whalebone, encases the patient. On the back of the jacket two strips of webbing are laid so that each strip crosses the other as a St. Andrew's cross. These are buckled to the sides of the tray, and effectively prevent the patient from moving in any direction, and keep him in the exact position which has been decided upon as desirable. The jacket should be laced and buckled over the front of the patient, as, in the case of children, mere buckling will not prevent the child from untying the straps and himself altering the position. There is no difficulty in applying the head- and leg-extension to the patient while he is in the apparatus.

"In those cases where the angular curvature is very prominent and pressure-sores may occur if the back is not frequently looked at, Mr. H. J. Gauvain uses a back-door splint (Fig. 481) or the swinging splint

FIG. 481.—"Back-door" splint, applied to patient (H. J. Gauvain).

(Fig. 482). In Fig. 483 a special form of splint is figured, modelled on that in use at Berck-sur-Mer."

Full details of the apparatus will be found in Mr. Gauvain's article, entitled "The Mechanical Treatment of Spinal Caries," *Lancet*, March 4, 1911.

(B) THE TREATMENT OF TUBERCULOUS ABSCESS OF BONY ORIGIN BY ASPIRATION AND INJECTION

Messrs. Jaques Calvé and H. J. Gauvain have contributed to the *Lancet*, March 5, 1910, a valuable paper on this subject. Briefly their remarks are as follows: They favour conservative methods in preference to all others, they insist upon all cause of local irritation being removed, they enforce early immobilisation of the injured part, and immobilisation should be prolonged in the normal position for a very considerable period. They find, as other observers have done, that some abscesses disappear and others cease to enlarge. If, however, an abscess in spite of the most approved general and local treatment continues to increase, Messrs. Calvé and Gauvain aspirate. Their technique is as follows: The strictest asepsis is observed, and "they use an all-glass syringe of 10 to 15 cc. capacity, with a trocar, a cannula, and a blunt-pointed probe which is exactly the same size as the trocar. This probe is used for freeing the lumen of the cannula if it becomes blocked by caseous pus. The cannula should have a lateral opening, and should not be supplied with a tap, as this is unnecessary. The length of the cannula should be at least 12 cms., so that the deep abscesses can be reached and plenty of healthy tissue

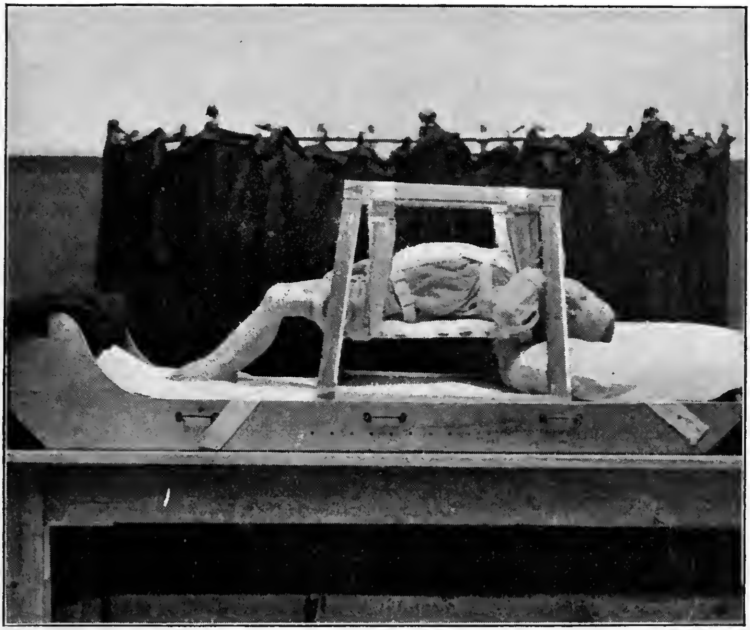

FIG. 482.—Swinging "Back-door splint." The head and legs here form a natural means of extension (H. J. Gauvain).

traversed before the abscess cavity is opened. The calibre of the cannula should not be too large, as a large bore will predispose to sinus-formation. The best calibre is from 1·8 to 2 mms. Over the spot, where the aspiration is to be made, a sterilised towel is placed, and in it is an aperture about the size of a five-shilling-piece. Through this aperture the aspiration is made. A local anæsthetic of ethyl-chloride is usually all that is required. The trocar should be inserted through as thick a layer of healthy tissue as possible before the abscess cavity is entered; and, where possible, the highest point of the abscess cavity should be penetrated, as aspiration into the dependent parts of the abscess is more likely to result in the formation of a sinus than if the upper part of the abscess is tapped. Two movements should be employed in the insertion of the trocar: the first a sharp one perforating the frozen skin; the second, slow and methodical, guides the point of the trocar into the abscess-cavity, it often being possible to hold the abscess itself in the left hand. The trocar is now withdrawn and the pus escapes with more or less ease. It is desirable to aspirate gently and avoid any violent manipulations. If the opening in the cannula be blocked by caseous pus it can be cleared by the insertion of the probe. In the removal of the cannula it is often advisable to aspirate with the syringe, as the vacuum thus obtained keeps in the cannula the fluid which it

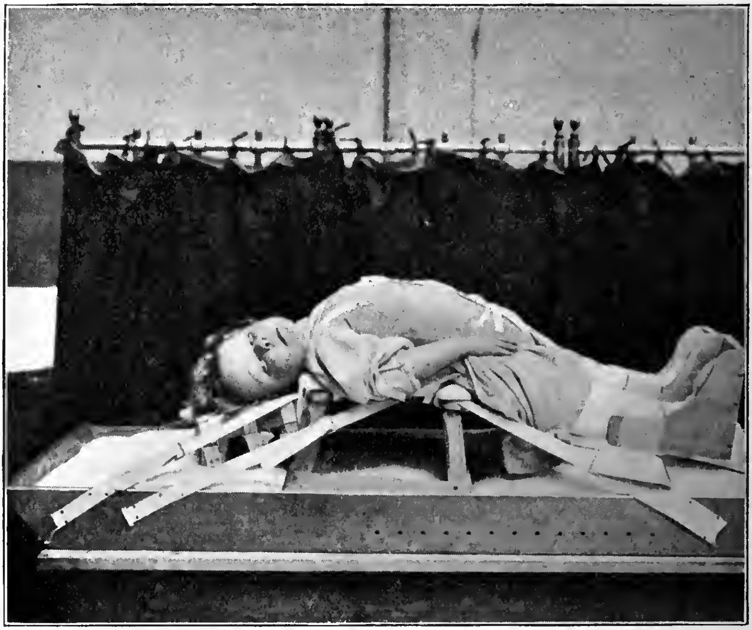

FIG. 483.—"Wheel-barrow" splint, indicated where there is spasm of the psoas muscle and psoas abscess (H. J. Gauvain).

contains, and prevents its escape into the track whilst it is being withdrawn. As soon as the cannula is removed, the track it has left should be squeezed between the fingers; and, after having washed the part with alcohol and ether, a dressing should be placed over the minute wound, which will keep it closed and compressed. More than one aspiration may be required. If, on the second aspiration, the pus is more sanious and presents a more fluid appearance this is said to be an indication of an approaching cure." Messrs. Calvé and Gauvain are in the habit of injecting either iodoform or camphorated-thymol into the abscess-cavities after the aspiration. They find the following preparations efficacious, namely, iodoform, 5 grammes; ether, 10 grammes; guaiacol and creasote, 2 grammes each; and sterilised olive oil, 100 cc. Or, they use iodoform combined with ether, the dose of iodoform-ether being 2 to 5 cc., and in others who tolerate it well doses of 10 cc. Camphorated-thymol is prepared by mixing two parts of camphor and one part of thymol, and 2 to 3 cc. are usually sufficient for one aspiration.

Iodoform-ether appears to act as a drying and as a sclerosing agent, but its use is contra-indicated if the pus in the abscess is caseous. It is then preferable to use an oily solution, instead of an ethereal solution. If, however, caseous pus is present camphor-thymol is preferable, as it has a true liquefying action on the caseous masses. If the fluid which has accumulated in an abscess after an injection of camphorated-thymol be examined, the caseous masses are no longer found in it, but it is merely viscous. The indications for aspiration and injection are as follows :—

(1) "When a simple aspiration is sufficient to empty the contents of the abscess, even though such aspiration may have to be repeated, a cure may be obtained without further operative treatment and without injection.

(2) "If, in spite of repeated simple aspirations, the pus re-collects more abundantly each time, the abscess increases in size, and the walls do not show any signs of becoming denser by the formation of fibrous tissue, then iodoform-ether will be indicated on account of its drying and sclerosing properties.

(3) "If the contents of the abscess are caseous, then camphor-thymol injections are recommended.

(4) "If the abscess increases rapidly, is extensive, the tissues around are being infected, and the general condition of the place is unsatisfactory, then an oily mixture of iodoform containing creasote and guaiacol should be used."

APPENDIX IV

FÖRSTER'S OPERATION FOR SPASTIC PARALYSIS

Since the introduction of this operation the literature of the subject has become somewhat extensive, and will be found on pp. 245-246 of the *Proceedings of the Surgical Section of the Royal Society of Medicine of London*, 1911. The operation consists essentially of dividing the posterior spinal nerve-roots for pain such as persistent neuralgia, tabetic crises, and some cases of spastic paralysis.

In his address to the Royal Society of Medicine, on June 13, 1911, Professor Förster gave a table of 28 cases of gastric crises operated upon, of which 25 survived and 23 were successful. He also gave a table of 81 cases of spastic paralysis, of whom 72 survived the operation, and 55 of the operations appeared to have been successful, and 8 patients were improved. Förster points out that spastic paralysis is due to disease of the cortico-spinal path, especially the pyramidal tract. These paths carry two kinds of fibres :—

(*a*) Those directing the motor impulses.

(*b*) The inhibitory fibres, which check the sensory stimuli, entering into the grey matter of the spinal cord by the sensory nerve roots.

When the latter are damaged the sensory afflux acts, unrestrained, upon the muscles, thus causing the spastic symptoms. If, in such cases, the posterior roots, that is to say, the paths of afferent sensory impulses, are cut, the excess of sensory impulses is again reduced, and the spastic symptoms are diminished or may even disappear completely. Frequently the fibres carrying the motor impulses are still fairly intact. In such cases resection of the posterior roots is followed by complete disappearance of the spasms; and all those voluntary movements, which were before so seriously interfered with by the spastic resistance of the muscles, are now executed without any difficulty. We may therefore conclude that the operation can only be successful where voluntary excitability of the muscles is still present to a certain extent. Further, this treatment can only cure those spastic conditions of the muscular system which are actually due to the influx of *sensory* stimuli to the grey matter of the cord, that is only in true reflex spastic contraction of the muscles. On the other hand, resection of the posterior nerve-roots cannot be successful in the muscular contractions of athetosis, chorea, and mobile spasms. All this latter class of diseases, which have been so often confused with the former, are due to the direct pathological action of *motor* centres and paths belonging to the cerebrum and mid-brain. For this class of case the operation is not applicable.

Some very remarkable results have been obtained and photographs are found in the issue of the *Proceedings of the Royal Society of Medicine* alluded to above. It may be remarked that, for athetosis with early reflex spasticity, the resection of the posterior roots removes the spasticity, whilst the athetosis does not disappear, or only for a short time.

The question whether any voluntary motility remains may be decided by preliminary injections of stovaine, which temporarily removes the spasms. The arm, as a general rule, is less suitable than the leg. In any case the disease must have become practically stationary. In the after-treatment of these cases assiduous attention must be given to skilfully planned exercises, and to the use of orthopædic apparatus which maintains the limbs in the best possible position. In the case of spasticity of the legs the 2nd, 3rd, and 5th lumbar, and the 2nd sacral sensory roots may be divided on each side; and a rule laid down by Förster is, that it is not advisable to divide more than two consecutive roots in any position, so as to avoid producing definite anæsthesia of the legs and removing the complete sensory innervation of any group of muscles.

At the same meeting of the Society Mr. Ernest W. Hey Groves gave an address, introductory to the discussion of Förster's operation, and quoted two cases where the operation had been done by him for persistent neuralgic pain, one case of gastric crisis, and three cases of spastic paralysis. In performing the operation he approves of Taylor's suggestion of a hemi-laminectomy in the cervical region, as it affords ample room for dealing with the posterior roots on both sides. In the lumbar region, however, this form of laminectomy is not applicable, as the parts are so deeply placed. Mr. Groves does not advocate the performance of the operation in two stages: first, the removal of the laminæ; and, secondly, the opening of the dura mater. He believes that the shock is due to the excessive bleeding and to the long time taken in arresting it; and he follows the plan, suggested by Braun, of injecting two to three ounces of a 1 in 50,000 solution of adrenalin into all the subcutaneous and muscular tissues, and he finds that the operation becomes an almost bloodless one.

Dealing with the lumbo-sacral roots, he says it is easier to attack the lower roots at the point where they all lie close together at their origin from the spinal cord. It is usually quite sufficient to take away the laminæ of the 11th and 12th dorsal and of the first lumbar vertebræ, to expose fully the roots of all the lumbar and sacral nerves. The differentiation between the anterior and the posterior roots is much easier at the level of the cord than at the exit from the dura. The only disadvantage of the high attack on the roots is in the difficulty of identifying the various nerves. This may be overcome by observing that the third sacral root is the last of any size to be given off from the conus medullaris. This root need never be cut for the relief of spasm of the leg muscles, because it is associated with the buttocks and perineum only. The root above it, namely, the 2nd sacral, is the first to be divided, and then each alternate root is severed, about one centimetre being excised.

INDEX OF AUTHORS QUOTED IN TEXT[1]

ABBREVIATIONS :—Cong. = congenital ; displ. = displacement ; tal. = talipes ; anat. = anatomy.

[1] The names of authors referred to in the footnotes are not indexed.

INDEX OF SUBJECTS

ABBREVIATIONS :—Anat. = anatomy ; T. = talipes ; cong. = congenital ; int. = internal ; ext. = external ; disloc. = dislocation ; T. eq. = talipes equinus ; T. calc. = talipes calcaneus ; T. var. = talipes varus ; T. valg. = talipes valgus ; T. eq.-var. = talipes equino-varus ; T. eq.-valg. = talipes equino-valgus ; T. calc.-valg. = talipes calcaneo-valgus ; T. calc.-var = talipes calcaneo-varus ; inf. paral. = infantile paralysis.

THE END

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