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DISEASES

OF THE

URINARY AND MALE SEXUAL ORGANS

BY

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PREFACE.

When the preparation of this volume was undertaken, it was the author's hope to present a résumé of current knowledge of the topics herein discussed, with comments suggested by personal observation and experience. In the execution of this plan he has been seriously embarrassed by the brevity of the period allotted for the work, which has permitted no opportunity for a minute scrutiny of pertinent literature, for a careful revision of the text, nor for the addition of a bibliography. Yet, as the patience of the publishers has been already severely tried by the author's unavoidable tardiness, he prefers to submit the original draft of the book, incomplete and crude as it may seem, rather than to postpone still further the appearance of a volume long since due.

There is a generally admitted tendency in medical practice to regard diagnosis as a recognition of morbid symptoms only, to neglect an inquiry into the cause of the phenomena, and hence to practise a routine treatment of *symptoms* rather than an individual treatment of *patients;* this tendency contributes largely to what Dr. Bartholow terms "the indiscriminate drug administration which is one of the evils of the time." While it must be admitted that in many instances treatment can be, in the present state of medical knowledge, only empiric, symptomatic, or tentative, yet it is equally certain that available means for ultimate diagnosis—and hence opportunities for rational treatment—are not universally utilized in medical practice.

Convinced that a lack of care and thoroughness in the investigations of patients is responsible for many failures in the management of urinary and genital disorders especially, the author has endeavored to present fully the necessity and the means for diagnosis as an essential preliminary to treatment. To this end he has devoted a considerable

portion of the book to a discussion of means for the recognition of morbid conditions; has emphasized the familiar but frequently neglected facts that cystitis, gleet, albuminuria, spermatorrhœa, are not entities calling for a routine administration of drugs, but symptoms requiring a thorough investigation of the patient; that the microscopical examination of urethral and seminal discharges is quite as essential for the recognition of sexual disorders, as is a similar inspection of the urine for the detection of renal diseases; in short, he has endeavored throughout the volume to portray the important bearing upon treatment of the pathological factor in diagnosis.

W. T. BELFIELD.

46 CLARK STREET, CHICAGO,
November, 1884.

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DISEASES

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CHAPTER I.

ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS.

The Kidney.

This organ is, in consequence of its anatomical relations, so inaccessible to all methods of direct examination, that we are largely dependent for our knowledge of its condition upon the examination of its secretion, the urine. Yet there are a few points concerning it, not recognizable by means of the urine, which may have great practical importance.

The slight attachment of the kidney to the surrounding tissues results in the easy displacement of the organ, a fact which has as yet scarcely received the general recognition which it deserves. Unlike the other abdominal viscera, the kidney is provided with no ligaments or other special means of support. The position of the gland, separated as it is from the abdominal organs by the peritoneum, and protected by the spinal column and the last two ribs, secures it in great measure from direct violence; while the nature of its functions requires neither of the kidney itself nor of the organs with which it is physiologically connected, any change of position in the body. Hence the anatomical provisions for the maintenance of its position are very slight. These consist partly of the vessels which enter and leave it, but largely of the peritoneum and of the adipose tissue which surrounds it and the suprarenal capsule; for the kidney lies between the serous portion of the peritoneum on its anterior surface and the fibrous layer which covers its posterior surface.

These attachments afford a support which is by no means inconsiderable. While the vessels which connect the kidney with the aorta and vena cava are quite elastic and easily permit a rather extensive range of movement on the part of the kidney, yet the connective-tissue attachments between the renal capsule and the adjacent peritoneum and fat are quite firm. Their importance can be readily demonstrated on the cadaver by

severing the renal vessels, after which it will be found that the usual force is required to remove the organ.

While these attachments suffice doubtless in the great majority of individuals to prevent dislocation of the kidney, yet in numerous instances they are overcome by various causes. This loosening and displacement of the kidney from its natural position has been often recognized, and doubtless exists far more frequently than we are in the habit of believing. It is generally regarded as an anatomical curiosity, rather than a clinical possibility to be kept in mind in the differential diagnosis of abdominal complaints. Displacement of the kidney has been often overlooked, partly because of the difficulties of diagnosis, but largely because the physician or surgeon has neglected the possibility of its occurrence. In a recent work Buret has collated more than fifty instances in which obstinate and serious affections were ascribed during life to various causes, and found post-mortem to be caused by displaced kidneys. In no instance was the true cause of the difficuity ascertained before death, and in very few was there even a suspicion entertained that the symptoms observed might be due to displacement of the kidney. In those cases in which no tumor was detected, the complaint was pronounced neuralgia, hysteria, chronic peritonitis, renal colic, etc.; in other cases in which a tumor was distinctly recognized, the swelling was considered an enlargement of the gall-bladder, ovarian cyst, tumor of the liver, enlargement of the liver, displacement of the spleen; in short, the greatest ingenuity was exhibited in devising mistaken diagnoses, presumably because the possibility of displacement of the kidney had been ignored. Ebstein records a case in which delivery was twice seriously impeded by a tumor which could be felt from the vagina. At the autopsy, many years later, this tumor was found to be a deeply situated kidney.

So long as the treatment is confined to the administration of drugs, failure to recognize displacement of the kidney, though resulting in lack of success in treatment, can hardly lead to the commission of disastrous blunders; but in these latter days of abdominal surgery, especial care and attention to this possibility is required before operative interference is undertaken. A striking example of the clinical importance of this point occurred in the experience of Billroth. At the time when this distinguished surgeon performed his first excision of the cancerous pylorus, in February, 1881, his colleague Bamberger had under treatment a middle-aged, emaciated woman, who had long exhibited the symptoms of chronic gastric difficulty, and who had a distinct firm tumor at the pyloric extremity of the stomach; she was believed to have cancer of the pylorus. Encouraged by the recovery and apparent cure of the patient from whom Billroth had excised a pyloric cancer, this patient of Bamberger expressed her willingness to undergo the same operation. After satisfying himself as to the necessity for it, Billroth began the operation for excision of the pylorus by incision through the abdominal wall. He found, however, no cancer nor other disease of the pylorus, but an atrophied displaced kidney pressing upon the duodenum. The kidney was removed and now adorns Billroth's museum; the patient died of collapse in twelve hours.

The fact that the most important supports of the kidney are the peritoneal folds accounts for the frequency of renal displacement in women (99¼ per cent. of all cases), and explains its almost exclusive occurrence in those women who have borne children. For the laxity of the abdominal walls caused by repeated pregnancies permits the intestines to drag heavily upon their peritoneal attachments and thus indirectly loosen the

kidney; possibly an enlarged and displaced womb may by traction on the ureter favor the same result. The absorption of perinephritic fat which accompanies general emaciation also weakens the renal attachments; yet while doubtless favoring renal displacement, emaciation is by no means an essential factor for its occurrence. The alleged relative frequency of wandering kidney in emaciated individuals is probably one of diagnosis only; for mobility of the kidney is found post mortem quite as frequently in stout as in spare persons, though for obvious reasons it is recognized during life almost exclusively in the latter class.

While such abnormality in the position of the kidney, congenital or acquired, is in general amenable only to surgical treatment, yet a correct diagnosis is a matter of importance to the physician, and often affords the patient great satisfaction, by dispelling the fear of graver difficulty. In all cases of obscure affections of the abdominal organs, and in pelvic, lumbar, and crural neuralgias, a careful palpation of the normal renal region should be made. In case of a failure to locate the kidney by external manipulation, information can often be derived by exploration through the rectum.

Albuminuria without renal disease has been observed in several cases of wandering kidney. Since any impediment to the escape of urine through the ureter may, by increasing the pressure in the urinary tubules, cause albuminuria, the occurrence of this symptom in cases of displaced kidney is quite comprehensible. For in consequence of the displacement the passage of urine through the ureter may readily be impeded either by pressure of this duct against adjacent organs, or by the existence of a sharp curvature in the ureter itself. Successive changes of position of a wandering kidney may cause intermittent albuminuria, which may be productive of diagnostic errors if the renal mobility be not discovered and properly interpreted.

The relation of the kidney to the lower ribs is a matter of much interest to the surgeon. As a rule, the kidney may be said to extend from the eleventh rib almost to the crest of the ilium. In some cases the twelfth rib is so short as to be readily overlooked, the eleventh rib being then mistaken for the twelfth; this error may lead to serious consequences, as was illustrated in an experience of Dumreicher. In performing a nephrotomy, he made the incision as usual from the lower border of the last rib. To his surprise he discovered that he had opened the pleural cavity. At the autopsy it was found that the twelfth rib in this case was only $3\frac{1}{2}$ cm. long and had been regarded as the spinous process of a lumbar vertebra, the eleventh rib having been mistaken for the twelfth. Incited by this accident, Holl examined the ribs of sixty skeletons, and as a result came to the following conclusions: complete absence and abnormal brevity of the twelfth rib occurs more frequently in men than in women, and on the right than on the left side. In these cases the position of the diaphragm is not changed, but a portion of it and of the pleura is unprotected by the ribs, and is easily injured by an incision extending to the lowest (eleventh) rib. It is, therefore, desirable that in every case of operation in this vicinity the ribs should be counted from above downward and the incision limited to the level of the twelfth rib, even though this bone be absent.

The absence of one kidney is a comparatively rare occurrence and yet one possessing great clinical importance. For it is especially in those cases in which the urinary excretion must be performed by a single organ that interference, natural or otherwise, with the functions of the organ causes the greatest risk to the patient.

The congenital absence of one kidney is so rare as to be an anatomical curiosity; I have been able to find only fifty-four cases recorded in the literature of the subject. Yet it must be remembered that an acquired defect of one kidney—the abolition of its function by atrophy, fatty degeneration, cystic degeneration, unrecognized hydronephrosis, etc.—is by no means a rarity. In these latter days operations upon the kidney, nephrectomy and nephrotomy, have become recognized surgical procedures; and more than one surgeon has, after the performance of a brilliant and skilful operation, seen his patient die of uræmia, and has discovered to his amazement, upon post-mortem examination, that the kidney operated upon was either the only one possessed by the patient, or at least the only one capable of performing its functions. Now since in cases of congenital absence or acquired inefficiency of one kidney the other organ becomes hypertrophied and performs the functions of both, no evidence of such deficiency may be discoverable through the urine, since this is perhaps furnished entirely by one kidney; hence in such cases the operators have had no suspicion of the actual condition, notwithstanding a thorough examination of the urine previous to the operation.

Lange removed the right kidney in a woman forty-seven years old. The symptoms, which had existed for three years, had always indicated disease of the right kidney and had led to a diagnosis of pyonephrosis and cystic degeneration of this organ. The correctness of the diagnosis was established upon the examination of the extirpated kidney. The operation was skilfully performed and the patient reacted well; yet complete anuria followed and the patient died on the fourth day of uræmia. The autopsy showed that the left kidney, which had always been considered healthy, was also far advanced in cystic degeneration; its pelvis and ureter were completely obliterated.

Dr. W. M. Polk, of New York, extirpated a misplaced kidney in a girl nineteen years old. The patient died eleven days later of uræmia, and the autopsy revealed the congenital absence of the other kidney. In his report of the case,[1] Dr. Polk refers to other instances in which the same operation has been followed by the same result from the same singular cause.

Such cases have been hitherto quite rare; but with the increasing frequency of operations upon the kidney they will doubtless become more numerous. Hence it becomes an imperative duty for the surgeon who contemplates an operation upon the kidney, to bear in mind the possibility of such untoward accident, and to take every precaution against its occurrence by ascertaining the presence and condition of the remaining kidney. Fortunately this can be done with certainty in females at least, by catheterizing the ureter, a manipulation to be presently described. A congenital absence of one kidney has been in many though not in all cases associated with malformation, anomaly, or defect in other urinary or in the genital organs. Thus in one case in which the left kidney was absent, the left seminal vesicle was very small; in other instances a corresponding arrest of development of the testicle has been observed. In women anomalies of the vagina and uterus have been repeatedly noticed in cases of congenital absence of one kidney. Such malformation has therefore diagnostic value in a doubtful case.

That the kidney is a *portion of the urinary channel* as well as a secreting organ is a patent and clinically important fact. We are familiar with the

[1] New York Medical Journal, February 17, 1883.

observation that chronic obstruction to the evacuation of urine is regularly followed by dilatation not only of the bladder and ureters, but also of the pelvis of the kidney and of the renal tubules; and it is equally true, though not so familiar, that the sudden removal of such obstruction is usually followed by hyperæmia and even inflammation of the previously distended channel.

It is a frequent clinical observation that the sudden removal of a long-standing impediment to the evacuation of urine is followed by serious local and even general disturbance on the part of the patient. Thus if an old and narrow stricture be cut or rapidly dilated; if a bladder which is in a state of dilatation in consequence of chronic enlargement of the prostate be opened for the removal of a stone, or even simply evacuated by the introduction of a catheter—in these and analogous conditions the patient suffers from chill, fever, often hæmaturia, anuria, cystitis, or even suppurative nephritis. The injury is usually manifested primarily and chiefly by the bladder; cystitis and pericystitis occur first, and may constitute the entire affection. Yet in these cases post-mortem examination often shows also an intense congestion of the entire urinary tract above the former impediment; hemorrhages in the kidney as well as in its pelvis are not infrequent. In other cases the sudden evacuation of the bladder is followed by complete anuria and death. In these instances post-mortem examination may show no acute affection of the urinary tract except an intense congestion of the kidneys.

The explanation of this congestion, hemorrhage, and inflammation in the kidney and of anuria following the sudden evacuation of a chronically distended bladder, is found in the anatomical relations of the vessels to the renal tubules. For the minute branches of the renal artery and vein, conducting the blood to and from the cortex of the kidney, lie closely packed between the straight tubules in the medullary portion; only a very small amount of connective tissue—the stroma of the kidney—intervenes between the blood-vessels and the tubules; the two sets of vessels are indeed practically in contact. Now the tubules of the kidney are in cases of tight stricture or enlarged prostate kept distended with urine whose escape is prevented by the impediment below. This distention of the tubules must of necessity take place largely at the expense of the contiguous blood-vessels, which are correspondingly compressed. So soon as the impediment—the stricture, for instance—is removed, the kidney tubules are emptied, and the habitually compressed blood-vessels suffer engorgement, which may be so great as to cause rupture of the vessels and escape of blood into the tubules and hence into the urine, or even anuria.

This congestion of the urinary tract in consequence of the sudden relief from chronic distention is designated as "negative pressure" or "hyperæmia ex vacuo." It is a frequent occurrence clinically, and constitutes the explanation of many familiar and unpleasant facts in the surgery of the urinary organs; a general recognition of its importance would obviate some of the disastrous complications which are so common in the treatment of bladder, prostatic, and urethral diseases. As already stated, the bladder suffers primarily and often most severely; for the chronic distention begins in this organ and may indeed be confined to it without materially increasing the pressure in the ureters and kidneys. Yet while inflammation of the bladder as the result of negative pressure may perhaps be controlled, participation of the kidney constitutes an irremediable and almost invariably fatal complication; hence the propriety of mentioning the subject here.

Every surgeon of experience has seen cases illustrating the principle

already stated, though perhaps not recognized as such. It is a familiar clinical fact that one of the perils attendant upon lithotomy in elderly men is the danger of cysto-pyelitis and suppurative nephritis; and it is a further fact that these occur as a sequel to the operation chiefly, if not exclusively, in those cases in which the bladder has been habitually distended with more or less residual urine. Lithotomy is notoriously safer in boys and youth than in elderly adults, merely because in the former class the bladder and kidneys have not been distended through prostatic enlargement, or stricture. Many cases are on record in which serious, even fatal hemorrhage and partial or complete suppression of urine have followed the simple introduction of a catheter in cases of prostatic hypertrophy or narrow stricture. The occurrence of fever after the rapid dilatation of a stricture, after the complete evacuation of the bladder in elderly persons, and after the operation of sounding for stone, is so common that the term "urethral fever" has come into general use to designate them. This term is, when applied to these cases, usually a misnomer. There are doubtless many cases of fever following the introduction of an instrument into the bladder, which can be plausibly ascribed to the impression made upon the urethra; but in the class of cases under discussion the clinical symptoms and post-mortem appearances show that the phenomena observed are to be attributed, not to irritation of the urethra, but to the congestion of the urinary tract, including the kidneys, caused by "negative pressure."

The same principle is illustrated in other pathological conditions. Thus it has been repeatedly observed in cases of glaucoma that the sudden relief of the habitual tension in the eye consequent upon the performance of iridectomy, has been followed by hemorrhage into the vitreous and retina, though these have suffered no direct injury during the operation; the removal of fluid from the pleural and peritoneal cavities, in cases of chronic pleurisy and ascites, has been similarly followed by hemorrhage from the vessels of the serous membranes which were thus suddenly relieved of an accustomed pressure. The oozing of blood from the walls of an abscess, after evacuation of the pus, is a familiar example of the same principle—engorgement and rupture of vessels from the sudden removal of accustomed pressure.

The practical deductions to be made from this intimate association of the kidney with the lower portion of the urinary channel will be discussed in connection with the use of instruments in the bladder.

It will suffice here to mention an instance showing that the kidney also is involved in the general congestion: Hofmokl relates a case in which he performed lithotomy upon an old man who had prostatic hypertrophy and consequent dilatation of the bladder. A few hours later there occurred profuse hemorrhage, which, however, was not from the lips of the wound. Death occurred twenty hours after the operation. At the autopsy there was found intense hyperæmia of the entire urinary tract, engorgement and miliary hemorrhages of the kidneys, and fresh extravasation of blood between the left kidney and its capsule.

The Pelvis and Ureter.

The presence of supernumerary pelves and ureters is a not infrequent anomaly, though one which possesses but little clinical interest. Three and even four ureters have been found in the same individual, each sometimes pervious throughout, though in the majority of instances at least one of the superfluous ureters is occluded at some part of its course.

The abnormal insertion of the ureter into the pelvis is a matter of clinical importance, since it is often responsible for cases of hydronephrosis in which no impediment in the urinary channel is discoverable during life. It has been repeatedly observed in cases of supernumerary ureters, the result being partial or complete hydronephrosis, according as one or all of the ureters were thus abnormally inserted. Such anomalous insertion is a congenital malformation and of course irremediable ; yet the possibility of its occurrence should be borne in mind in forming an opinion as to the character of an abdominal tumor ; for the absence of any history of renal calculi and of other causes for hydronephrosis has repeatedly misled experienced surgeons, even Billroth himself, into an erroneous diagnosis of ovarian tumor, where the lesion was really hydronephrosis.

The abnormality of this insertion is usually that the ureter opens obliquely into the pelvis, just as its lower extremity opens into the bladder. In another class of cases the ureter is inserted on the side instead of at the bottom of the pelvis, often at the anterior or external surface. This malformation results necessarily in the retention of some urine in the pelvis of the kidney, that which escapes being as it were the overflow from the distended pelvis. In some of these cases the recumbent position favors the escape of urine from the pelvis, so that a tumor which has existed at night has almost or quite disappeared in the morning.

Kupfer's researches into the development of these organs explain some of these congenital anomalies. He found that the ureter at first opens as a short canal into the posterior wall of the Wolffian body, and is at a certain period turned toward the back of the embryo. At a later date the Wolffian body and ureter make a half revolution (180 degrees) on its axis, the posterior portion now becoming anterior. Sometimes this revolution is not completed, in which case the insertion of the ureter will of course be on the anterior, external, or even posterior wall of the kidney. He observed seven cases of such anomalous insertion of the ureter, in four of which hydronephrosis was present.

A more frequent anomaly consists in the *presence of valves* either at the renal orifice or at certain points in the ureter. These valves, which are merely folds of superfluous mucous membrane, seem to originate in the excessive length of the embryonic ureter (which is developed independently of the kidney). Such valves are found far more frequently in the fœtus and in young infants than in adults. Wölfler examined the ureters of 50 new-born children ; in 20 of these he found from one to five more or less marked folds of mucous membrane which were situated always and exclusively at the same point, namely, one to one and a half centimetres from the pelvic orifice. In most of these there was a dilatation, more or less pronounced, of the pelvis ; in 10 the ureter was almost or quite impermeable. In 50 adult cases, on the other hand, he found not a single such fold, indicating that they are often obliterated with age ; yet they sometimes persist, and become more pronounced with advancing age, causing decided hydronephrosis. Thus Billroth operated upon a case in which there was no history to indicate the possibility of hydronephrosis ; the tumor present was considered ovarian, even after the abdominal incision. The cause of the hydronephrosis was a (probably congenital) semilunar valve of mucous membrane at the pelvic orifice of the ureter. The arrangement is likened by Wölfler, who reports the case, to a small aortic valve with sinus Valsalvæ and coronary artery, the latter corresponding to the ureter. The pressure of this valve against the wall of the pelvis by the enclosed urine completely obstructed the ureter. The history of the case showed

that this closure must have been for a long time temporary and transient, and that it had been increased by repeated pregnancies; in fact the closure had been constant (as shown by the permanent increase of the tumor) since the last pregnancy, three years previously.

The anatomical relations of the ureter in the lower part of its course have, especially in females, great practical importance; for the ureter passes along the side of the supra-vaginal portion of the uterus and of the vagina; hence displacements, enlargements, and tumors of the uterus, and perimetritic inflammations, may cause an angular curvature of one or both ureters sufficient to obstruct the passage of the urine.

The result of such obstruction may be *albuminuria* or even *hydronephrosis*. Hildebrandt relates two cases in which he was enabled to demonstrate the dependence of hydronephrosis upon retroflexion of the uterus. In one case the patient complained of extreme pain during micturition, and exhibited a large fluctuating tumor in the left iliac region. Hildebrandt regarded the swelling as a hydronephrosis produced by obstruction to the ureter caused by the flexion of the uterus, and demonstrated the correctness of the diagnosis by first straightening the uterus with a sound, then introducing a catheter and pressing upon the abdominal wall over the tumor; the swelling rapidly diminished in size and a copious flow of urine immediately followed.

The occurrence of hydronephrosis in consequence of cancer of the uterus is a frequent and familiar observation. Blau found that distention of one or both ureters occurred fifty-seven times in ninety-three cases of carcinoma uteri. The immediate cause of death in this affection is often uræmia. The obstruction to the flow of urine appears to be sometimes the result of implication of the ureter in the neoplasm, while at other times the ureter itself shows no signs of cancerous disease, but is merely compressed by the enlarged cervix or the thickened periuterine tissue.

Albuminuria may also occur in consequence of the obstruction to the flow of urine caused by compression or curvature of the ureter associated with displacements or enlargements of the uterus—a fact of diagnostic importance; for it is well known that an increased pressure of urine in the ureter and pelvis is of itself sufficient to cause the escape of albumen from the glomeruli. This has been demonstrated experimentally by compression of the ureter, and is seen clinically in cases of hydronephrosis in which the ureter is still pervious; for in such cases the urine is transiently or constantly albuminous. The fact that albuminuria may thus result directly from displacements of the uterus or from periuterine inflammations is not so generally recognized as to make it possible to secure data to establish the frequency of such occurrence. I have myself seen one case in which the relation of cause and effect seemed clearly demonstrated. A lady thirty-five years old, the mother of four children, had been frequently troubled since her last confinement, eighteen months earlier, with difficulty in micturition. The act was accompanied with considerable pain and had to be repeated at short intervals. These symptoms had been especially annoying during the last four months. Her last labor had been somewhat difficult and had been followed by periuterine inflammation. The urine had been found to contain albumen; the attending physician suspected Bright's disease. Upon examination I found the uterus somewhat enlarged and retroflexed; the urine contained a small quantity (about one-tenth per cent.) of albumen and an occasional hyaline cast, but was otherwise normal. Treatment was directed entirely to the uterus; in the course of a few months we were enabled to secure a decrease in the size

and an improvement in the position of this organ; meanwhile the albumen gradually disappeared from the urine, and the annoying symptoms during micturition ceased.

The normal enlargement of the uterus in pregnancy may likewise cause albuminuria by compression of the ureter; it would seem probable that a similar result may be produced by the pressure of ovarian or other tumors.

The albuminuria which is sometimes seen *in irritable states of the bladder* appears to be due to compression of the ureter by spasmodic contraction of the muscular coat of the bladder which is perforated by it. Such seems to be the explanation of the albuminuria which occurs when a gonorrhœal inflammation extends into the posterior urethra and involves the neck of the bladder; the irritation of the mucous membrane causes a spasm of the muscular layers, in consequence of which the distention occasioned by even an ounce or two of urine stimulates the organ to contraction. This same spasm causes compression of the vesical ends of the ureters; hence there results a frequent evacuation of small quantities of slightly albuminous urine. The same phenomenon is sometimes witnessed in consequence of the irritation caused by a calculus in the bladder. In determining the condition of the kidneys preliminary to an operation for stone, it should therefore be remembered that albuminuria may be due directly to the presence of the stone and not to renal disease; the microscope and the patient's symptoms must decide. In other cases spasmodic contraction of the vesical muscles—irritability of the bladder—accompanied by slight albuminuria, may be the result of irritation in the rectum, vagina, or uterus.

Tumors in the bladder may obstruct and displace the vesical orifices of the uterus and thus occasion albuminuria, or hydronephrosis, or both. This is true not only of those tumors whose size permits their detection, but also of minute growths in the bladder unrecognizable during life, and even by simple thickening of the mucous membrane. I have observed and recorded [1] a curious example of this nature. The subject was a man seventy-four years of age, dead of pneumonia. The muscular coat of the bladder was considerably thickened, and its mucous membrane in a state of catarrhal inflammation; there was decided enlargement of the middle lobe of the prostate. The left ureter was much dilated and the corresponding kidney was hydronephrotic; the right kidney and ureter were normal. The cause for the dilatation of the left ureter and kidney was found in a small tumor situated under the mucous membrane just below the orifice of the left ureter, which was thereby compressed and almost closed. This little tumor was no larger than a small pea, and was found to be a pure myoma. Neither its existence nor the hydronephrosis had been suspected during life.

The Bladder and Prostate.

The vascular supply of the bladder presents two points of clinical importance: first, the venous plexus in the neck of the bladder and prostate anastomoses freely with the radicles of the hæmorrhoidal veins; second, the blood returning from the bladder, seminal vesicles, and penis passes through the prostatic venous plexus. Zuckerkandl has demonstrated free

[1] Wiener Med. Wochenschrift, May 19, 1881.

communication of the prostatic plexus not only with the veins which empty through the internal iliac into the vena cava, but also with those which empty into the portal vein. This anatomical fact explains various familiar clinical observations: thus elderly men whose habits produce frequent or constant portal congestion, are often troubled with dysuria and even mild cystitis, from congestion of the veins around the bladder neck. In such subjects, especially if they also have prostatic hypertrophy, over-indulgence in the pleasures of the table may induce sudden retention of urine. This is caused by the congestion of the prostatic plexus in common with that of the portal system generally. Habitual portal congestion may result in varicosities of the vesical and prostatic veins known as "bladder piles," which are occasionally observed post-mortem; they may produce symptoms simulating stone and their rupture sometimes causes hæmaturia of obscure origin. These bladder piles are usually, though not always, associated with rectal hæmorrhoids. In a few instances hemorrhage has been observed alternately from the rectal and vesical hæmorrhoids; periods of hæmaturia alternating with hemorrhage of the piles. Chronic congestion of the prostatic plexus produced by portal congestion or habitual constipation, doubtless contributes largely to the prostatic hypertrophy which is frequent in old men; just as chronic venous congestion produces interstitial thickening elsewhere—in the kidney, the skin of the lower extremities, etc.

The veins of the penis empty into this prostatic plexus; hence the prevention of constipation is an important item in the treatment of inflammatory conditions of the penis, prostate, and other genital organs, as well as of masturbation, nocturnal pollutions, etc. For congestion of the portal or hæmorrhoidal veins or both—hence constipation—maintains a venous congestion of the prostate and penis; indeed it may aggravate or even induce in this way a constant irritation of the sexual organs, manifested by frequent erections and seminal emissions. Distention of the bladder with urine tends to produce the same effect by compressing the prostatic plexus—a fact familiarly illustrated in the erections which occur in healthy men before rising in the morning, when the bladder is filled with urine secreted during the night.

In some cases, probably more numerous than we are accustomed to suppose, the enlargement extends from the veins of the prostatic plexus to those returning along the wall of the urethra; at any rate, enlarged and tortuous veins are occasionally discovered with the endoscope in such cases. These veins may produce uneasiness and painful sensations along the urethra, and they favor profuse urethral hemorrhage upon slight provocation.

The vesical veins—those which return the blood from the general parenchyma of the bladder—also empty into the prostatic plexus; hence any influences which produces a congestion of this plexus tends also to induce general venous congestion of the bladder. Portal congestion, habitual constipation, prostatic enlargement may therefore all cause a derangement in the nutrition as well as the functions of the bladder. In mild grades this venous congestion of the bladder may be indicated merely by an increased production of mucus and by vesical irritability—both familiar symptoms of prostatic enlargement, if pronounced and persistent there may occur a decided increase in the connective tissue surrounding the muscular fibres of the bladder as well as some fatty degeneration of these fibres; the result is a loss of the usual muscular tone of the organ, a tendency to atony and dilatation. Sooner or later a catarrhal cystitis is de-

veloped from this venous obstruction caused by prostatic enlargement; just as eczema occurs on the leg from varicose veins.

The nerve supply to the bladder is also a matter of clinical interest. The neck of the bladder, including the sphincter, is supplied directly with spinal nerves, which proceed from the anterior roots of the third, fourth, and fifth sacral; the body of the bladder, on the other hand, obtains its nerves from the sympathetic hypogastric plexus. The spinal centre of the motor fibres is in the vicinity of the third lumbar vertebra.

This anatomical difference in the nerve supply of the different muscles of the bladder corresponds to the known physiological antagonism between the sphincter and the detrusor muscles. The former is, in the normal state, completely under the control of the will, while the latter is practically independent of volition. The act of micturition consists simply in the voluntary dilatation of the sphincter; the expulsion of the urine is an involuntary act, except as it is assisted by the contraction of the abdominal muscles. In cases of injury to the spine above the third lumbar vertebra, whereby communication between the brain and the spinal centre of the vesical nerves is interrupted, there occurs retention of urine in consequence of the inability of the patient to dilate the sphincter; when this muscle is dilated mechanically by the introduction of a catheter into the bladder, the detrusor muscles contract as before.

Another fact of clinical importance is the distribution of the same nerve (the pudic) to the base of the bladder and prostate, the integument of the penis, scrotum, and perineum, the urethral muscles and mucous membrane, and the sphincters of the anus; in the female the uterus, vagina, and vulva are supplied by branches of the same trunk, which is distributed also to the base of the bladder and urethra. As a result, irritation exerted upon these various organs—the urethra, rectum, anus, perineum, vagina, etc.—may be manifested by functional abnormality at the base of the bladder. It is a familiar clinical observation that irritability of the bladder, indicated by frequent and painful urination, may be caused by conditions of the most diverse nature in other portions of the area supplied by the pudic nerve. Thus fissures and ulceration of the rectum, habitual constipation, the presence of worms in the bowel, ulceration and inflammation of the uterus, the accumulation of smegma under the prepuce, phimosis, stricture, etc., may not only be accompanied by an irritable state of the bladder without actual lesion of this organ, but may even manifest themselves subjectively by sensations referred to the bladder rather than to the actual seat of the irritation. Hence it is necessary, in every case of obscure difficulty affecting the bladder—especially if the subject be a child—to examine also the various other organs to which the pudic nerve is distributed. Conversely an actual irritation of the bladder or prostate may produce abnormalities in the area named—rectal tenesmus, urethral spasm, nocturnal pollutions.

The sphincters of the bladder are in the male two in number: one consists of a ring of unstriped muscular fibres contained in the vesical border of the prostate; the other is the striped muscular tube which surrounds the membranous portion of the urethra. Stricker and Dittel demonstrated the function of these two muscular rings in the following way: A dog was curarized, whereby all striped muscular fibres, including those surrounding the membranous urethra, were paralyzed. The bladder remained full, no urine escaping. Even after a vertical section had been made through the prostate (excluding the posterior edge) no urine escaped. This constituted circumstantial evidence that the prostatic muscular ring performed the function of a sphincter. Positive demonstration was furnished by in-

[illegible] intestine filled with water from the bladder into the [illegible] and connecting it with a glass tube; electrization of [illegible] caused a decided ascent of the water in the tube. Since in [illegible] all striped fibres were incapable of contraction because [illegible] it is evident that the contraction observed must have been that [illegible] fibres in the prostate.

[illegible] sphincters, the internal or prostatic and the external or [illegible] seem essential for perfect continence and control of the urine. [illegible] serious impairment or lack of development of one or the other [illegible] is accompanied by incontinence of urine. Thus, previous to puberty, enuresis appears often to be the result simply of a lack of development of the internal sphincter; for this sphincter is a part of the prostate, and this gland, in common with the genital organs generally, remains undeveloped during the first years of life. The compressor urethræ, surrounding the membranous urethra, which is a striped muscle and under voluntary control, suffices for the closure of the bladder during the waking hours; but in sleep this control is less perfectly exercised, and because it is not reinforced by the internal sphincter, nocturnal incontinence often results.

At puberty the prostate participates in the general development of the sexual organs and the internal sphincter performs its full functions; at this time, if not before, nocturnal incontinence usually ceases. In comparatively rare cases, enuresis persists after puberty, even until the individual attains the age of sixteen, eighteen, or twenty years; in such cases there is an imperfect development of the sexual organs.

The enuresis or "weakness of the bladder" of old men can often be traced to an impairment of the prostatic sphincter. In these cases there is, as Dittel has shown by microscopic examination, a fatty degeneration of the muscular fibres of the bladder and prostate, including the internal sphincter. Fatty degeneration of the sphincter only or chiefly is manifested by incontinence of urine; when it affects the detrusor muscles also, the ability to expel the urine is impaired; these are the cases in which sudden paralysis of the bladder occurs in consequence of overdistention, from holding the urine too long.

Fatty degeneration may affect the sphincter in cases of prostatic hypertrophy, but is more frequent when the prostate is atrophied; this atrophy occurs oftener than enlargement (according to Dittel twice as often) even in old men. It is an occasional result of gonorrhœa; hence there is sometimes seen as a sequel to gonorrhœa, even in young or middle-aged men, a "weakness of the bladder," which may manifest itself by actual incontinence, but more frequently takes the form of dribbling after micturition; sometimes there is merely a necessity for frequent and immediate urination.

Impairment of the external sphincter, the internal remaining intact, is also at times the cause of incontinence. This happens usually as a result of stricture. An inflammatory deposit involving the membranous portion of the urethra must of course impair its muscular contraction; and as a clinical fact such impairment, manifested by enuresis, is frequently observed in cases of stricture involving the posterior urethra.

Even a stricture in the pendulous portion may occasion the same result. For when it becomes quite narrow there occurs a chronic distention of the urethra posterior to the stricture; and this may extend so far back as to dilate the membranous portion of the canal, depriving it of its normal contractility. Dilatation of the stricture cures the enuresis by permitting the compressor urethræ once more to resume its functions.

In the female the entire urethra, corresponding to the membranous portion of the male, is provided with circular muscular fibres, and performs the function of a sphincter. Cases have been observed by Winckel and others in which the neck of the bladder and the upper portion of the urethra had been entirely disorganized by vesico-vaginal fistula, and in which after the closure of the fistula by operation, the remaining external portion of the urethra had been found sufficient to constitute a perfect sphincter.

The external, voluntary sphincter may in various conditions cease to obey the will. Thus in cases of irritation at, or operation upon the anus or perineum, in states of mental tension, such as prolonged nervous excitement, hysteria, sexual exhaustion, etc., there may occur a spasmodic contraction of this muscle which no effort of the will is able to overcome, the use of the catheter being necessary. In other cases the opposite condition occurs, the sphincter dilating without voluntary impulse or even in opposition to the will. Thus terror, nervous shock of any kind, and even inordinate laughter may be accompanied by an involuntary dilatation of the sphincter and expulsion of urine.

The position of the vesical orifice of the urethra with reference to the symphysis is a matter of clinical importance. It is as a rule located in adults about one inch behind and three-fourths of an inch above the arcus inferior of the symphysis; in children it is always higher, sometimes even above the bone. The position is influenced by the inclination of the pelvis; for the urethra is firmly bound to the pelvis in front of and underneath the symphysis; hence the inclination of the latter influences the position of the bladder neck. In youth the symphysis is more inclined than in age, and the position of the vesical orifice is correspondingly higher. The distention of the rectum and of the ischio-rectal fossa is another factor which increases the height of the neck of the bladder, for since this cannot recede from the symphysis, such distention must raise the vesical orifice toward the upper border and compress it against the symphysis. Hence it sometimes happens that fleshy old men, in whom the ischio-rectal fossa is full of fat, must defecate before they can urinate, since while the rectum is distended the neck of the bladder is high and the prostatic urethra compressed. In cases of prostatic hypertrophy the vesical orifice moves upward and backward from its normal position.

The trigonum—the triangular portion of the floor of the bladder whose angles are located at the vesical orifice of the urethra and of the two ureters respectively—is distinguished normally by an abundance of muscular tissue. The upper border of this triangle, stretching between the orifices of the ureters, sometimes becomes hypertrophied so as to constitute a ridge which opposes the entrance of the catheter. In a few recorded instances this ridge has become so developed as to constitute a partition between the body of the bladder and that portion below the ureters. In one case observed by Dittel this muscular layer completely shut off the lower section of the bladder from the body of the organ, so that at the autopsy, after the catheter had reached and evacuated the former, the bladder still remained full, and was emptied only by a special effort whereby the catheter was forced over the obstruction.

Hernia of the bladder, extrusion of the whole or a part of the organ, may occur through the abdominal wall, the inguinal or crural canal, through the foramen ovale, into the perineum, scrotum, labia, vagina, or urethra. The most frequent forms are, in males, the scrotal; in females, vaginal, femoral, and urethral cystocele. These are comparatively rare conditions;

yet the possibility of their occurrence should be remembered, since a failure to recognize them may be followed by disastrous results. In many of the recorded instances, the true nature of the hernia has not been discovered until after death from operation; since the diagnosis is usually easy, by observing the decrease in the size of the tumor after the introduction of the catheter, such mistakes usually result merely from lack of care, and not from inherent difficulties in diagnosis.

Inguinal hernia of the bladder is usually a complication of ordinary intestinal or omental hernia, though in a few rare cases cystocele has been found to constitute the entire hernia. It may comprise almost the entire organ or only the fundus, which is connected with the base of the bladder by a narrow channel passing through the inguinal canal. In these latter cases, in which a portion of the bladder is thus cut off from the remainder and protrudes into the scrotum, calculi may form in the extruded portion. Vidier refers to a case in which a cystocele containing a stone was considered a bubo, and caustic was applied, resulting in the production of a urinary fistula. Adhesions of the bladder to the adjacent intestine or sac have been frequently observed.

In the female, inguinal cystocele is less frequent than in males. It may constitute a swelling of the labium, and may possibly be mistaken for distention or abscess of the vulvo-vaginal gland.

Vaginal cystocele occurs especially in women who have borne children and have suffered laceration of the perineum; it may also result from displacements of the uterus; indeed, a slight degree of displacement of the floor of the bladder is a not uncommon feature in uterine complaints.

In cases of vesico-vaginal fistula there sometimes occurs an eversion of the bladder through the opening, forming a red, soft tumor which blocks up the vagina. Crosse saw a case in which the bladder after eversion into the vagina had actually escaped between the labia, forming a tumor external to the vulva, from which the urine dripped continuously; the orifices of the ureters could be detected.

Inversion of the bladder through the dilated urethra has been observed in females, especially during infancy; it may even be congenital. In adults, it occurs as the result of chronic cystitis, with constant and violent efforts at micturition. In most of these cases the entire parenchyma of the vesical wall is displaced; but in a few instances the mucous membrane has been detached from the muscular coat and has protruded alone. Noel records a case in which obstruction to the ureters had caused the urine to burrow between the mucous and muscular coats of the bladder; the mucous membrane protruded through the urethra in the form of a transparent sac filled with clear liquid.

Urethral cystocele has been mistaken for a polyp.

Displacements of the bladder may exist for years without causing symptoms referable to this viscus; and may even then cause a difficulty suggesting disturbance in other abdominal organs. A curious instance of this sort is recorded by Dr. Briddon.[1] In this case a boy nine years of age exhibited symptoms of fecal impaction and perityphlitis. A fluctuating tumor occupied the right inguinal region, extending as high as the umbilicus. There were no symptoms indicating urinary difficulty. After making an incision parallel with and one inch above Poupart's ligament, it was discovered that this tumor was the laterally situated and distended bladder.

[1] Medical Record, November 26, 1881.

Dr. T. G. Thomas has called attention to the occasional adhesion of the bladder to an ovarian tumor, resulting in a spreading out of the bladder, like an apron, over the anterior surface of the tumor as high or even higher than the umbilicus. In seven cases recorded, the case had terminated fatally either from direct injury to the bladder—the surgeon failing to recognize the complication—or from failure to remove the tumor on account of the adhesion. In a case in his own practice, Thomas succeeded in liberating the bladder from its attachments and removing the tumor, with favorable results.

Diverticula—loosely called "cysts" of the bladder—protrusions of the mucous membrane between the muscular fibres—are frequently found. In some cases these have no especial clinical importance; but in most instances these protrusions are found in elderly men who have long suffered from prostatic hypertrophy or from stricture of the urethra. In such individuals these diverticula constitute an important factor in explaining the origin and obstinacy of vesical catarrh. For since these sacs consist merely of mucous membrane devoid of muscular fibres, they are never emptied by the contractions of the bladder; indeed they are aggravated and increased in size by such muscular action. The urine, therefore, is not expelled from them, but stagnates indefinitely; the urinary salts are precipitated and accumulate, sometimes aggregated as calculi. A cystitis which originates from any cause is prolonged indefinitely in these sacs; for no medicated injection can be made to enter them thoroughly, nor can the stagnant urine and products of inflammation be removed from them, without especial effort.

These sacs frequently perplex the surgeon in still another way, namely, by preventing him from touching with the sound a stone which the symptoms prove to exist. In many cases the stone is formed and remains in the diverticulum; in other cases a calculus formed elsewhere drops into the sac, where it may remain permanently or only transiently. Sometimes the stone is found now in the diverticulum and again in the body of the bladder, according to the movements of the patient. In such instances the surgeon often becomes an unwilling party to a game of hide-and-seek in his search after a stone, sometimes reaching it with the sound at the first attempt, but failing at subsequent sittings to detect it. Sir Benjamin Brodie relates an instance in which he discovered a stone in the bladder of a man, who however declined an operation. "He went on, in general suffering little or nothing. Every now and then, however, he was suddenly seized with the usual symptoms of stone in the bladder, and very severe ones too. He then sent to me. I kept him in the horizontal posture, prescribed him an opiate clyster, and in the course of a few days, sometimes sooner, sometimes later, the attack subsided, he was again at his ease and enabled to return to his usual habits. I had been occasionally in attendance on him for three or four years, when he was seized with a severe cold, which ended in a pleurisy, of which he died. On examining the body I found the stone imbedded in a cyst near the fundus of the bladder. The cyst was formed in this case not by the protrusion of the mucous membrane between the muscular fibres, but by a dilatation of both tunics of the bladder, the muscular as well as the mucous. The stone was not so closely embraced by the cyst as to prevent it occasionally slipping out of it, and I suspect that this actually happened, and that it was when the stone lay in the cyst that the patient was free from the usual symptoms of calculus, and that his sufferings took place when the stone escaped from it into the general cavity of the bladder."

In occasional instances these sacs have been known to attain enormous size. In one case reported by Dr. Murchison to the London Pathological Society, there was a large abdominal tumor extending as far as the spine of the ilium, the exact nature of which was determined only by puncture and examination of the fluid withdrawn. Fifty-four ounces of urine escaped in half an hour through the puncture and through a catheter simultaneously introduced into the bladder.

Coulson quotes from Warren the following case: "A man aged eighty-five, who had suffered from dysuria for several years, met with an accident which caused his symptoms to increase. His abdomen gradually became enlarged as though he were suffering from ascites, and only a small quantity of urine could be obtained by the catheter. On examination after death the tumor, which reached as high as the stomach, was found to have been caused by an enormous diverticulum from the bladder, the walls of which were much hypertrophied. On the left side, a little above the neck, was a round opening leading into the larger tumor, which was formed of the peritoneal and mucous coats and held a gallon of urine. From the history of the case it was evident that the prostatic enlargement had led to hypertrophy of the muscular coat. At the time of the injury this tunic had given way, and as time went on the mucous and peritoneal coverings had become distended and formed the enormous cyst."

These diverticula are usually the results of a chronic impediment to the evacuation of urine—chiefly prostatic hypertrophy and urethral stricture; they are therefore commonly observed in elderly adults. They sometimes occur in children also, being frequently produced by tight phimosis or narrowing of the meatus, and they have been seen in cases in which there was no discoverable impediment to the evacuation of urine, and therefore no appreciable cause for their existence.

Erichsen mentions a case in which a smooth, fluctuating tumor was found extending from the stomach into the pelvis, in a man thirty-five years old. The tumor could be felt through the rectum, though there was no difficulty in defecation or urination. It was punctured and seven pints of clear urine withdrawn. The patient died of syncope. At the autopsy there was found dilatation of the bladder, ureters, and renal pelves, and two cysts, one on each side, which communicated with the bladder by openings large enough to admit the finger. These were diverticula from the bladder, opening into its cavity about an inch and a half above the orifices of the ureters. The most singular feature of the case was the entire absence of mechanical impediment in the urinary channel; both the prostate and urethra were normal.

Holmes observed a case in which a large congenital cyst consisting of mucous membrane and peritoneum communicated with the bladder. This was apparently a congenital malformation. Many of the cases of so-called double bladder appear to have been instances in which congenital cysts or diverticula as large as the bladder itself existed. Thus Heyfelder detected by the sound a calculus in the bladder of a boy six years of age. After performing lithotomy, the surgeon failed to find the stone. At the autopsy it was found that the bladder consisted of two cavities, an anterior and a posterior, connected by an orifice large enough to permit the passage of a sound; the stone was discovered in the posterior portion, which consisted of mucous membrane and peritoneum.

The prostatic urethra or prostatic "sinus" is sometimes, especially in cases of great hypertrophy of the prostate, so capacious as to accommodate a large quantity of fluid. In a few recorded instances the surgeon

has been deceived into supposing that the catheter had entered the bladder, when in reality it rested in the dilated prostatic sinus, from which a considerable quantity of urine had escaped.

The so-called "middle lobe" of the prostate is merely a portion of the gland uniting the two lateral lobes which constitute the bulk of the organ. This middle lobe may be much enlarged without any decided increase in size of the remainder of the prostate. It is situated posterior to the vesical orifice of the urethra, and when enlarged it projects from behind forward over this orifice.

The absorbent power of the vesical mucous membrane has been the subject of much discussion and experimentation. Various authors have been unable to demonstrate such power of absorption and have utterly denied its existence; among these is Sir Henry Thompson. More extended and accurate observations have, however, demonstrated that the normal mucous membrane of the bladder absorbs, though far more slowly than mucous membranes generally. The reason for this difference appears to lie in the absence of secreting (and therefore absorbing) glands. For the epithelium of the bladder consists of several layers of cells, the uppermost of the squamous variety; this is practically impervious to fluids. It is only the follicles, which are lined with a single layer of cells, that offer a favorable opportunity for absorption; and in the bladder these follicles are few and are located almost exclusively in and around the trigonum.

In cases of disease or injury to the mucous membrane, whereby the normal epithelium is removed, absorption may occur with extreme rapidity, a fact to be remembered in the use of injections into the bladder in cases of cystitis, hemorrhage, etc.; for when the lining epithelium is removed, either by instruments or by morbid conditions such as catarrh and ulceration, the contents of the bladder are brought into close proximity to the vessels of the submucous tissue, whereby absorption is facilitated.

The mucous membrane of the urethra presents a marked contrast in this respect to that of the bladder, since it readily and quickly absorbs. This fact—which possesses physiological rather than clinical interest—is readily explained by the anatomy of the part; for the urethra is lined by only a few, in some parts by a single layer of cylindrical cells, and is richly provided with secreting and absorbing follicles.

The tolerance of the bladder to mechanical and chemical irritants is remarkable, and is scarcely appreciated. Strong solutions of nitrate of silver and even the undiluted solution of the perchloride of iron have been injected into the bladder without provoking a pronounced reaction or causing much pain. This can be safely done only through a perineal opening; for the urethra is extremely sensitive, and a few drops of such solutions applied to it cause intense pain and sharp inflammatory reaction. Hence such irritant solutions should not be injected through the urethra, since it is practically impossible to prevent contact with the mucous membrane of this channel. When, however, the bladder has been rendered accessible by a perineal incision, either for exploration, lithotomy, or for the relief of cystitis, strong solutions may be employed, if necessary.

The Urethra.

The mucous membrane of the urethra is furnished with numerous microscopic racemose glands, called Littré's glands. There are, moreover, in the mucous membrane tubular pockets, the so-called lacunæ of Morgagni, which may have the depth of an inch or even an inch and a half.

These are located chiefly upon the roof of the urethra, though also found in its sides and floor. In the interior portion of the pendulous urethra these pockets attain their greatest depth, and are usually located so that their open extremities are toward the meatus; in the posterior portion of the pendulous urethra and in the membranous part, on the other hand, the open ends of these pockets are turned inward, that is, toward the bladder. This is not an occasional or exceptional arrangement, as might be inferred from the standard text-books on anatomy and on genito-urinary diseases, most of which assert that the lacunæ all open toward the meatus; a few mention the fact that in a few instances such follicles have been seen opening inward toward the bladder. In reality the lacunæ of Morgagni exhibit in every urethra, male and female, this diversity of arrangement—those of the anterior portion opening outward and those of the posterior portion opening inward—a fact which I presented and illustrated to the Royal Society of Physicians in Vienna in 1881.

Whether or not this peculiar arrangement of the lacunæ in the posterior portion of the urethra has special clinical importance, remains to be proven. During the discussion in the Vienna Society it was suggested by Professor Dittel that the obstinacy of gonorrhœa in some cases might be due to the participation of these lacunæ in the posterior portion of the urethra; that the inflammation may persist in these follicles, inaccessible to injections or other medication, after the general urethritis has subsided. It would also seem that these lacunæ afford a favorable opportunity for the accumulation of urinary salts; possibly folliculitis, which sometimes occurs independently of gonorrhœa as well as during the course of that inflammation, is favored by the anatomical arrangement of these lacunæ. In the female I have repeatedly found, post mortem, these follicles distended with epithelial débris and inspissated pus, even to the size of a hazel-nut.

In the female the follicles are unusually deep and numerous at and around the external orifice of the urethra. In 1854 Singer, then assistant in the Clinic for Syphilis in Vienna, demonstrated the dependence of obstinate gonorrhœa upon the participation of these lacunæ; in several cases of gonorrhœa, both vaginal and urethral, the discharge persisted in spite of all medication until applications were made directly to these individual follicles. As their orifices are located external to and just below the meatus, they can be easily slit up if necessary. In the male, too, a similar measure may be necessary. Phillips (quoted by Bumstead and Taylor) states that he cured four obstinate cases of gleet "by introducing a director along the upper surface of the urethra until its extremity entered the lacuna magna, and then slitting up the wall of the follicle with a narrow bistoury."

The mucous membrane of the urethra in the male is, in the flaccid condition of the penis, thrown into numerous transverse and longitudinal folds. These favor the arrest and retention of solid ingredients of the urine which may be precipitated in the bladder; they constitute, moreover, one of the obstacles to the introduction of instruments. If the urethra were more generally examined at autopsies, and especially if the examination were made *in situ*, the occurrence of such folds as a pathological factor would probably be demonstrated more frequently. Possibly some so-called strictures of large calibre, congenital and acquired, are really due to unusually large folds of urethral mucous membrane.

Saccular dilatation of the urethra is occasionally witnessed, not only as a result of stricture, but also without apparent causes. In the few cases which have been observed in females, it was assumed that the dilatation

had been furthered by compression of the urethra by the child's head during confinement. Such dilatation sometimes causes uneasiness and pain during micturition, dribbling of urine, and may even induce a slight gleety discharge from the irritation of the mucous membrane caused by the retained urine. In females, and often in males, a slight protrusion can be detected in the course of the urethra; yet the dilatation may be discoverable only by the use of the urethrometer or endoscope.

Congenital abnormalities of the urethral mucous membrane are not infrequent, and possess considerable clinical importance. Among these are occlusion of the canal by simple adhesion of its walls, hypertrophy of the epithelium, saccular dilatation, and congenital stricture. These may occasion retention of urine in the new-born, and various anomalous symptoms, such as enuresis and dribbling, in subsequent years; an unsuspected dilatation and hypertrophy of the bladder, nephritis, and even uræmia (seldom recognized as such), may occur in a child as the result of an undiscovered congenital impediment to the evacuation of urine.

Occlusion of the urinary channel *through the simple adhesion of opposing mucous surfaces* occurs in varying degree and at different localities of the urethra. The adhesion of the prepuce to the glans is a frequent occurrence in the new-born, and is known to cause numerous morbid symptoms. The examination of the parts, and if necessary the separation of the prepuce from the glans, should be made at the birth of every male infant.

Adhesion not infrequently occurs between the lips of the meatus, and may exist anywhere in the course of the urethra. Englisch, who has investigated particularly this subject, found forty-six cases of simple adhesion between the walls of the urethra in new-born infants.

In other instances the occlusion of the canal consists not in simple adhesion of the mucous surfaces, but in an obliteration of the urethra to a greater or less extent by cicatricial tissue. The same observer collected 39 cases of this sort in infants; 14 were found in the fossa navicularis or at the meatus, 6 in the membranous and 2 in the prostatic portion; in 1 case the entire urethra was obliterated, and in 6 others the canal was occluded at several places.

Englisch has also called attention to the congenital *occlusion of the orifice of the sinus pocularus*, in the prostatic urethra, as the cause of retention of urine in the new-born. Such occlusion is followed by the distention of the sinus through the accumulation of secretion from the glands lining its walls. He found this abnormality in over seven per cent. of numerous dissections of infants; sometimes the sinus was distended to only a slight degree, constituting an unimportant encroachment upon the prostatic urethra; in other cases it was so distended as to rival the bladder in size, constituting a fluctuating tumor extending from the posterior margin of the prostate and filling up the space between the bladder and rectum even as high as the recto-vesical fold of the peritoneum. In most of these cases the bladder, ureters, and kidneys exhibited the inevitable effects of urethral impediment to the evacuation of urine; hypertrophy and dilatation of the bladder, hydronephrosis, and even atrophy of the kidney was found in infants as the result of this distention of the utriculus. The possibility of this abnormality should be remembered in those cases of retention of urine in the new-born in which no occlusion of the urinary channel is visible; the impediment is readily overcome by a catheter, and the utriculus can be emptied by pressure between a sound in the urethra and a finger in the rectum.

Congenital organic *strictures* of the urethra are most frequent at the meatus and in the fossa navicularis, though they are also observed at the bulbo-membranous junction. It is noteworthy that in many of these cases phimosis also exists. This condition of the prepuce should therefore be regarded as an indication for the exploration of the urethra in those cases in which obscure urinary difficulty persists after the removal of the phimosis. In cases of congenital as well as of acquired stricture, there may occur dilatation of the urethra and even urinary fistula posterior to the stricture; in other instances there may be nothing to arouse suspicion of congenital stricture except incontinence or dribbling of urine. I have seen a boy ten years of age, who had always exhibited incontinence of urine in an unusual degree, the urine frequently escaping involuntarily during the day as well as by night. After the measures usually employed had been fairly tried, and had failed to improve this condition, the urethra was explored and a stricture, apparently organic, which tightly grasped a Charrière No. 7, was found at the junction of the bulbous and membranous portions. The stricture was slowly dilated, after which procedure perfect continence of urine followed.

The conditions just described constitute constrictions of the urethra of such small calibre as to be readily appreciated by the ordinary instruments used for exploration; the fact that such decided strictures have been so often recognized as congenital makes it probable that congenital strictures of larger calibre than the meatus, and therefore not discoverable by the usual modes of exploration, which cannot be distinctly recognized, exist and are overlooked. To Dr. Otis, of New York, belongs the credit of having first devised and practised accurate methods for discovering such strictures of large calibre. The experience of Otis and of the numerous surgeons who have been induced to employ these methods has demonstrated the existence of such strictures in a certain percentage of cases. The clinical importance of these strictures has doubtless been overestimated by enthusiasts; yet there can be no question that they are at times responsible directly and indirectly for various abnormalities of sensation and function in the genito-urinary tract—gleet, nocturnal pollutions, etc.

The urethral mucous membrane may exhibit marked *hypertrophy*, the thickening constituting in fact a stricture. In these cases there is usually some increase in thickness in the submucous connective tissue, but the epithelium itself presents the thickening in much greater degree. I have myself examined post-mortem two cases in which the epithelium was about one-twentieth of an inch in thickness, the section resembling the skin from the palm of the hand. In one of these cases the subject was a man thirty-nine years of age, who had experienced an attack of gonorrhœa, and who had an ordinary cicatricial stricture under the hypertrophied mucous membrane; the other subject was a man twenty-one years of age, who, so far as known, had never had gonorrhœa, and whose urethra was otherwise normal. In both cases the hypertrophy existed about half an inch in front of the bulb; in each there was some increase of the submucous connective tissue below the epithelial thickening.

Hypertrophy of the verumontanum is occasionally observed, possibly as a result of masturbation; in one case I have seen it enlarged to at least three times its usual volume. In this subject there was a decided distention of the right seminal vesicle in consequence of the impervious condition of the ejaculatory duct, which was compressed by and in the hypertrophied tissue. In a few rare cases the veru montanum has attained an enormous size. Civiale mentions two such instances; in one recorded by De Blegny

it was as large as a small walnut; the ejaculatory ducts were distended, and contained several hard concretions as large as peas. In the other case the veru montanum was still larger. Both subjects were old men.

The muscles of the urethra possess much importance for the diagnosis and treatment of urinary and genital disorders. To the disordered action of these muscles, stimulated by irritation either in the urinary channel, in adjacent pelvic organs, or even in distant parts of the body, are attributable many of the so-called functional disorders of the genito-urinary organs, such as enuresis, irritable bladder, dribbling and retention of urine, abnormality in the ejaculation of semen; indeed there can be no doubt that organic stricture of the urethra itself can be so closely simulated by spasmodic contractions of the urethral muscles as to deceive the surgeon.

The following muscles are so situated as to compress by their contractions various portions of the urethra:

1. A ring of unstriped muscular fibres situated in the posterior portion of the prostate and surrounding the vesical orifice of the urethra (the internal sphincter).

2. Unstriped fibres in the pubo-prostatic ligaments, drawing the bladder and prostate toward the symphysis.

3. Unstriped fibres in the ischio-prostatic ligament, compressing the prostatic urethra from above. This muscle and the pubo-prostatic fibres probably assist in the ejaculation of semen.

4. Striped muscular fibres—the transversus perinei profundus muscle—lying immediately behind the anterior layer of the triangular ligament and enclosing the membranous urethra and Cowper's gland.

5. Striped circular fibres (continuous with the last named) surrounding the membranous urethra.

All these muscles (excluding the internal sphincter) are collectively termed by Hyrtl the compressor urethræ; they constitute the external sphincter of the bladder.

6. The bulbo-cavernosus, which arises from the central tendon of the perineum, encloses the bulb of the urethra, passes forward on either side of the penis, surrounds the corpora cavernosa, and terminates in a membranous expansion on their upper surface. This muscle is a powerful compressor of the urethra, whose action is witnessed in the jetting expulsion of the last drops of urine; it assists in the erection of the penis by compressing the dorsal vein and the erectile bodies.

7. The corpus spongiosum is richly provided with unstriped circular fibres throughout its whole length; indeed Stilling describes the spongy body as a "muscle through which the urethra runs."

Irregular contraction of one or more of the urethral muscles is a not infrequent occurrence in individuals who have suffered from disease of the urethra or even of the rectum. In cases of catarrh of the bladder neck following gonorrhœa, and of exhaustion from sexual excesses, masturbation, stricture, etc., there is often some irregularity in urination; the patient feels a frequent desire to empty the bladder, but accomplishes the act with difficulty; he may be compelled to wait for some minutes before he can void the urine, notwithstanding the fact that he experiences an urgent desire and makes every effort by contraction of the abdominal muscles so to do. In other instances the stream is small and occasionally interrupted; there may be a dribbling of urine immediately or some minutes after the conclusion of the voluntary act.

Irritation in the rectum may occasion similar irregularity of the ure-

thral muscles; operations upon the anus or rectum are frequently followed by complete retention of urine owing to the reflex spasm of the urethral muscles.

Simple nervous excitement or exhaustion may arouse such spasmodic contraction of the urethral compressors as to render urination temporarily impossible. In such cases the introduction of the catheter reveals a decided obstacle to its passage—a spasmodic stricture.

The possibility of spasmodic stricture is practically denied by Sir Henry Thompson. Of it he says: "It is an exceedingly useful excuse for the failure of instruments. It is a refuge for incompetence. Spasm may prevent the urine from going outward; I do not know that it ever prevents the instrument from going in." Notwithstanding Sir Henry's scepticism there can be no doubt that spasmodic contraction of the urethral muscles may attain such a degree as to oppose and even temporarily prevent the entrance of a catheter. Surgeons who certainly understand the introduction of the catheter, and who need no "refuge for incompetence," have placed upon record instances of spasmodic stricture. Thus Dittel has seen it as the result of simple acidity of the urine and in cases of diabetes mellitus, irritation of the anus by worms, fissures, etc.; and he narrates several cases in which no other cause than mental excitement could be assigned. A Vienna physician was called to see a lawyer who was preparing for a journey and suddenly suffered retention of urine. The physician attempted to introduce a catheter, but met an insurmountable obstacle in the membranous portion. The patient was taken to Dittel, who passed a No. 25 F. without trouble. Two years later the same phenomenon occurred in the same person. This time Dittel, in attempting to introduce a catheter, met an obstruction in the membranous portion, which yielded only after the catheter had been firmly pressed against it for fifteen minutes.

I was once consulted by a medical student, who upon the eve of an examination for which he had been industriously preparing, suddenly found himself unable to evacuate his bladder. By persistent straining he was successful in expelling only a very small amount of urine, which dribbled away in a small and jerky stream. He stated that for several days preceding the occurrence he had experienced difficulty in urination, being often compelled to wait some minutes before the urine would flow; and he sometimes felt sure that he had not completely evacuated the bladder. He had never had gonorrhœa nor any other affection of the urinary organs previous to that time. After several unsuccessful attempts to introduce different catheters, I succeeded in overcoming the resistance, which was located in the membranous portion, by continuous pressure for several minutes with a small conical metallic instrument. Curious to know whether or not this was an instance of spasmodic stricture, or merely of my "incompetence," I secured the patient's permission to try again, several days after he had successfully passed the examination. At this time I found no difficulty in introducing different catheters into the bladder.

That a spasmodic contraction of the urethral muscles should exist is certainly not remarkable. An analogous spasm of the sphincter ani is a frequent phenomenon in cases of ulceration of the rectum or fissure of the anus; indeed, in these conditions a spasmodic contraction of the sphincter of the bladder, causing complete retention of urine, is not infrequent. The sphincter of the vagina exhibits a similar spasmodic condition in cases of vaginismus.

It has been asserted that spasmodic contraction of the urethral muscles may exist for years, causing all the symptoms of organic stricture, and so

closely simulating this affection as to deceive the surgeon into systematic treatment by dilatation or urethrotomy. Tuffnell cites a case where a diagnosis of organic stricture of the membranous urethra was made; but after a tape-worm which the patient harbored had been expelled, the stricture and its symptoms vanished. Dr. Otis is especially sanguine in maintaining the possible permanence of spasmodic stricture, while nearly all surgeons consider it as always transient and temporary. He narrates several cases in his own experience which certainly corroborate his assertions, provided there has been no error of observation. In these cases the spasmodic contraction of the compressor urethræ has been, according to Otis, the result of irritation caused by a stricture of greater or less calibre in the anterior urethra; his usual experience has been that the catheter meets a decided obstruction in the membranous urethra, sometimes yielding to pressure, but often permitting only the smallest instrument to pass. After dividing the stricture in the anterior urethra, however, the largest sounds are passed into the bladder without obstruction at the membranous urethra.

At a meeting of the New York Pathological Society, March 8, 1882, Dr. Otis presented the urinary organs of a man who had for twenty years subsequent to a gonorrhœa suffered constantly from frequent, difficult, and painful urination. He had been under the care of many noted surgeons in Europe and America, including Sir Henry Thompson, Civiale, and Van Buren. Neither stricture nor vesical calculus had ever been detected, nor was there any enlargement of the prostate. Various diagnoses had been made. Otis discovered a stricture of large calibre near the meatus and divided it. The operation was followed by almost complete relief from the distressing symptoms, which had been nearly constant for many years, but the patient died on the ninth day from uræmia. The autopsy revealed hypertrophy of the bladder and dilatation of the ureters and pelves, but no mechanical impediment to the evacuation of urine. "Dr. Otis thought that in the absence of any other cause, absence of obstruction of any kind to account for the condition of the urinary organs, we must be permitted to suggest the possibility of all the difficulty having been produced by spasm reflected from irritation at a distant part. The case was strictly in line with cases which he had presented to the profession before, cases where cystitis, frequent urination, spasm at the neck of the bladder had continued for a long time, and apparently the only difficulty to which these symptoms could be attributed was contraction of the meatus urinarius, not greater than in the present case; and the proof that the supposition was correct was found in the disappearance of the trouble immediately after division of the contracted orifice."[1]

Such cases certainly prove that spasmodic contraction of the vesical muscles, even sufficient to produce hypertrophy of the bladder and consequent disease of the kidneys, can be exhibited for years without apparent and direct cause. While vesical spasm can certainly be produced by a urethral stricture, the other possible sources of irritation—in the urine, rectum, constitutional taint, etc.—should not be forgotten; and at the autopsy a careful examination of the urethra and bladder neck should be made *in situ*, since valvular folds of mucous membrane can be obliterated during the removal of the organ from the body.

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[1] Medical Record, April 8, 1882.

General Symptomatology.

Each of the morbid changes to which the urinary organs are subject is accompanied with certain definite symptoms generally recognized as characteristic of the affection. These will be mentioned in discussing these conditions individually. It is to be remembered that the patient's most prominent subjective symptoms often direct attention to some other than the diseased organ, and hence mislead the physician into an erroneous diagnosis.

The symptom which creates the greatest impression upon the patient, and to which he always assigns a prominent position in relating his case, is pain. Now there are two points to which pain is referred in nearly all affections of the urinary as well as of the genital organs: these are the neck of the bladder and the end of the penis. Pain at one or both of these points is a symptom of the most diverse disorders; it is felt not only in affections of the bladder, prostate, and urethra, but also in most inflammatory conditions of the ureter and of the renal pelvis; inflammation of the kidney itself, especially that which arises by extension from the pelvis, may be accompanied by pain at the neck of the bladder, though the region of the kidney is entirely free from pain and from tenderness on pressure. In females, affections of the uterus and of the periuterine tissues are frequently accompanied with pain and irritability at the neck of the bladder; indeed, a certain amount of dysuria is a regular accompaniment of menstruation in many women. Irritation of the anus and rectum, if severe, stricture, phimosis, contracted meatus, adhesion of the prepuce to the glans, and even an accumulation of smegma under the prepuce, may be responsible for uneasy sensations at the vesical neck.

Unusual concentration and acidity of the urine may produce not only a smarting sensation in the fossa navicularis, but also a heavy burning pain behind the symphysis and frequent painful urination. The surgeon is sometimes consulted by young men who are firmly convinced that they have contracted gonorrhœa, because they feel a smarting pain in the urethra and at the vesical neck during the frequent acts of micturition, following a night of debauch including impure intercourse. The symptoms are caused by the extreme acidity of the urine.

Dull pain felt at the neck of the bladder with or without frequent desire to urinate occurs in cases in which no local origin for the difficulty can be found either in the urinary or in the adjacent pelvic organs. In some of these cases the symptoms are evidently due to malarial, syphilitic, rheumatic, or gouty taint, since they are relieved by general treatment addressed to the removal of this constitutional taint. In still other cases similar symptoms appear as one of the numerous manifestations of neurasthenia, either general or sexual; just as attacks of severe neuralgia of the stomach occur from the same cause. A lady patient of mine, in apparently robust health, suffered for several months from occasional attacks of severe pain in the stomach, for which I could find no other explanation than general exhaustion from mental exertion and anxiety. These painful sensations of the stomach suddenly ceased, but were followed at intervals (independent of the menstrual function) by severe pains at the neck of the bladder, accompanied by painful and frequent urination. Similar attacks are sometimes witnessed in cases of hysteria, for which no reason other than the general condition can be assigned.

Pain referred to the region of the kidney is rarely caused by disease in the parenchyma of the organ itself, but is often produced by affections of the perinephritic tissues, the pelvis, and the ureter. For the kidney itself appears to be devoid of sensory nerves, which are, however, distributed to its capsule and the surrounding tissue and to the pelvis. The chronic forms of renal inflammation rarely cause pain in the kidney itself, though frequently inducing abnormal sensations at the neck of the bladder. Acute congestion of the kidney, distending its capsule; malignant growths; the excretion of highly concentrated and acid urine; perinephritic inflammation, pyelitis, disorders of the genital organs, sexual or general exhaustion, are responsible for the pain in nearly all cases in which this is referred to the kidney. In any of these conditions the pain may be felt along the course of the ureter, in the groin, on the inner surface of the thighs, and across the abdomen, even more acutely than in the lumbar region. On the other hand, cases are recorded in which these various conditions (excepting perhaps perinephritic inflammation) have occurred without causing enough pain to constitute a prominent symptom of the affection.

Diseases of the pelvis and ureter are usually accompanied by pain, though this is often referred to the bladder, genitals, sacrum, or hypochondrium, and not perceived in the loin or groin. This is especially often the case during the passage of renal stones.

In some instances pain is felt in the course of the ureter, though no renal calculi can be discovered even at the autopsy. In some of these the post-mortem examination has shown inflammation and even ulceration of the ureter. Thus Todd observed a case in which the patient had severe attacks of sharp pain, felt in the right loin and accompanied by obstinate vomiting. These attacks lasted for days or weeks at a time, after which he remained free from them for a variable period, the longest having been four years. The urine contained pus, but neither blood nor crystalline forms were discovered to confirm the diagnosis of renal calculus. At the autopsy it was found that the right ureter was thickened throughout the greater part of its length and its mucous membrane ulcerated at several points; no calculus was discovered.

There are cases, probably more numerous than we are accustomed to think, in which persistent and severe pain is experienced in the region of the kidney, independent of any morbid condition of this organ or its appendages. If there chance to be slight, perhaps transient, albuminuria (as so often happens without renal disease), the physician may be deluded into a diagnosis of renal calculi or even "Bright's disease." In such cases the pain may be due to some constitutional affection independent of the kidney; a history of malaria or syphilis, of gout or rheumatism can be elicited, or a state of nervous or sexual exhaustion be recognized. Allbut mentions several cases in which occasional attacks of abdominal pain simulating renal colic seemed to be dependent upon valvular cardiac disease with hypertrophy, or aortic aneurism. The dependence of pain in the back upon sexual excesses, usually ascribed by the alarmed patient to a kidney affection, is quite generally recognized by the profession; but the agency of the various constitutional taints enumerated in producing pain in the region of the kidneys is, as it seems to me, scarcely appreciated. Inasmuch as a verdict of Bright's disease is so terrifying to the patient, and if mistaken so disastrous to the physician, the possibility of these causes for pain over the kidneys, even when accompanied by albuminuria, should be remembered and investigated before a diagnosis is made.

Da Costa relates the following case as showing that the symptoms of renal difficulty can be closely simulated by malarial infection :

"A soldier, twenty-four years of age, of fair complexion, and evidently of strong constitution, was seized rather suddenly with pain over the left kidney. The loin was sensitive to the touch, and appeared somewhat red and swollen. The skin was hot ; the pulse 100. The urine was not found to be abnormal, though containing a reddish coloring matter. The pain continued for several days, becoming more severe, notwithstanding that, by Dr. West's direction, under whose charge the man was and with whom I saw him, six ounces of blood were drawn from near the affected part. On the fourth day of the disorder the patient was assailed with excruciating pain along the course of the ureter, attended with the voiding, at short intervals, of a high-colored urine. The attack lasted from six o'clock in the evening until five o'clock the next morning, leaving the patient much exhausted, the only relief throughout its duration being obtained from the inhalation of chloroform. At six o'clock in the evening another seizure of equal violence set in, and after the lapse of twenty-four hours again another. Seeing the recurrence of the paroxysms at about the same time of each day, and learning from the patient that a few months before he had had a remittent fever, which had left behind an irregular intermittent, we resolved upon the administration of large doses of sulphate of quinia in the interval between the paroxysms. The seizure did not take place that night ; but the remedy being a day or two afterward suspended, the fourth night was again a night of anguish. The antiperiodic was resumed and continued in lessened doses for three weeks. The patient remained, for about six weeks after the last attack, under Dr. West's observation, gradually recovering his health and spirits. When he was lost sight of there was still a dull pain in the left lumbar region, with inability to stand erect, but no return of the excruciating intermittent neuralgic pains."

A German mechanic, thirty-two years of age and of robust appearance, consulted me, saying that he was a sufferer from Bright's disease. For several months he had complained of a constant dull pain in the loins, occasionally aggravated by sharp lancinating pains, which extended into the groins, especially on the right side. His urine had been found by a physician to contain albumen.

Diligent inquiry into his history failed to reveal any features of renal disease, except that about two years previously he had had fever, headache, and some swelling of the feet, these symptoms lasting about a week. During this time he had not been confined to his bed, but had had pains in different parts of the body, especially in the loins. A careful examination of the patient failed to discover any symptom of renal disease ; there was no dropsy, no cardiac hypertrophy nor increased arterial tension, no polyuria, etc. The urine contained a trace of albumen ; in all other respects the secretion was normal.

Induration of the inguinal glands inspired questions regarding venereal disease, which resulted in the information that the febrile attack, already described as having occurred two years previously, had been preceded by a venereal sore and followed by a skin eruption. Assuming that the pain in the loins was probably an evidence of syphilis, and that the febrile attack three years previously had indicated the outbreak of the disease, I administered the usual antisyphilitic remedies, and in the course of a month had the satisfaction of curing the "Bright's disease," so far as the pain in the loins was concerned. Intermittent albuminuria persisted for some months.

A young farmer came to me in the spring of 1883 for the purpose of ascertaining whether or not he had Bright's disease. He had been working very hard for a year, had lost considerable flesh, his appetite was impaired, and his rest much disturbed by pain in the back of the head and in the loins. A physician had treated him for some time without marked benefit, had finally discovered albumen in the urine, and had expressed an opinion that the patient was a victim of Bright's disease. Of several other physicians who were subsequently consulted, some had confirmed while others rejected this diagnosis, according as they had or had not found albuminuria.

Upon presenting himself to me, the chief subjective symptom was the pain in the loins, usually of a dull aching character, but sometimes aggravated into a sharp pain, radiating from the back into the groin and testicle. The other symptoms indicated general neurasthenia. The patient had never had venereal disease, had lived in a malarial region, but had only once suffered from intermittent fever. The urine, examined on three different occasions, showed absolutely no abnormality except a somewhat high specific gravity. He was advised to take certain hygienic and medicinal measures addressed to the general health. Ten months later I saw him again in apparently perfect health.

Disorders of various of the genito-urinary organs may be manifested for a long time only by symptoms exhibited by other and distant organs, symptoms whose dependence upon the genito-urinary affection is obscure. That phimosis can be the cause of paresis of the lower extremities, and even of curvatures of the spine, has been asserted by Sayre and Otis; that sexual exhaustion is responsible for numerous and most diverse nervous symptoms has been especially illustrated and emphasized by Beard. Among these are dyspepsia, constipation, palpitation of the heart, dyspnœa, impairments of vision, numbness of the extremities and clamminess of the hands.

In the urinary apparatus proper, diseases of the kidneys are especially prone to cause affections of distant organs, whose origin may be long overlooked. Indeed we are so wedded to the notion that disease of the kidney is necessarily accompanied with albuminuria, and so negligent in the examination of the urine, that the absence of albumen, even if but one examination be made, is often regarded as conclusive evidence in excluding renal disease; and it but too often happens that unless there be special reasons for suspecting kidney disease, no examination of the urine is made.

Symptoms of the most diverse nature and affecting nearly all of the bodily functions, are known to result from chronic renal disease. The possibility of renal origin should be remembered in cases of disordered action of the heart, cardiac dilatation and hypertrophy, increased arterial tension, asthma and chronic bronchitis, dyspepsia and chronic gastritis, chronic or frequently recurring diarrhœa, persistent headache, sleeplessness, cerebral excitement, coryza, the impairment of vision, recurring inflammations of serous membranes; for any of these may exist for a considerable time without other symptoms directing especial attention to the urinary organs. Now among the numerous causes of renal disease are abnormalities, congenital or acquired, of the lower portion of the urinary tract. The dependence of pyelo-nephritis, hydronephrosis, and uræmia upon such anomalies as phimosis, contracted meatus, congenital stricture, etc., is demonstrated; in fact, so intimate are the anatomical and physiological relations among the different organs of the genito-urinary tract, so far-reaching and diverse the disorders originating in these organs, that no

examination is complete or satisfactory, whatever the supposed ailment of the patient, which does not include an inquiry into the performance of the genital and urinary functions. The degree to which this inquiry shall be instituted must of course depend largely upon circumstances. It is undesirable to attempt a complete examination without special reasons for it, and it is practically inconvenient or even impossible to make a critical examination of the entire urinary tract and of the urine in every case in a large practice. At present, however, errors of omission to investigate are certainly more frequent among general practitioners than mistakes of commission by overinvestigation. Every physician who makes a practice of examining the urine and the condition of the genito-urinary organs, even in cases which present no symptoms indicating disorders of these organs, must have seen instances in which the neglect so to do might have or actually has misled into an erroneous diagnosis.

CHAPTER II.

METHODS OF EXAMINATION.

When disease of the genito-urinary organs is suspected, a more or less critical examination into their condition is necessary. The means employed in making such examination will of course vary according to the nature and location of the supposed abnormality ; a suspected disease of the prostate requires other methods of exploration than a supposed disorder of the kidney. Yet since an affection involving one portion of the urinary tract frequently leads sooner or later to disorders in other organs, a critical examination of the entire urinary and even genital tract is often required.

Such examination may require several or all of the following methods of eliciting information :

1. Questions addressed to the patient.
2. Palpation, perhaps inspection of the abdomen, the groins, the perineum and external organs.
3. The introduction of the finger into the rectum (into the vagina in the female).
4. The introduction of the bulbous sound for exploring the urethra ; or the cylindrical sound or catheter into the bladder.
5. Examination of the urine.

The information acquired by these methods is usually ample for the determination of the nature of a given case. There are, however, additional means of exploration which are less frequently required, but which must be employed in certain cases where the ordinary means are insufficient. Among these are :

6. Conjoined manipulation, the sound in the bladder and the finger in the rectum or over the symphysis.
7. Inspection of the urethra through the endoscope.
8. Determination of the urethral calibre by the urethrometer.
9. The digital examination of the bladder. This is accomplished in the female by simple dilatation of the urethra ; in the male by urethrotomy in the membranous portion.
10. The introduction of two fingers or even the hand into the rectum.
11. The introduction of a catheter or sound into the ureter (practicable as yet in the female only).

Questions to the Patient.

These should be addressed not only to the condition of the urinary and genital function, but also to the general condition of the patient ; for certain affections of distant organs often direct especial attention to possible abnormal conditions of the genito-urinary organs. The questions directed to the state of the urinary function may well embrace the four inquiries

which Sir Henry Thompson advises as a uniform system in examining patients suspected of urinary difficulties. These refer to four symptoms and signs commonly observed in such cases—frequency of urination; pain in micturition; abnormality in the character of the urine; the addition of blood to the urine.

Frequency of urination is a symptom, more or less pronounced, in most affections of the urinary tract, excepting only certain diseases of the kidney. It may be due either to an excessive secretion of urine in consequence of which the bladder is filled and must hence be evacuated at unusually short intervals, or the frequency of urination may depend upon excessive sensibility at the neck of the bladder or in the prostatic urethra, with or without anatomical lesion in these parts.

Frequency of urination from increased secretion of urine is as a rule painless; from irritability of the bladder it is usually accompanied by a painful sensation during the act. There are, however, exceptions to both of these rules; frequent micturition dependent upon hysteria, for example, is often accompanied with decided pain, and the same symptom may be observed in cases of polyuria with pyelitis; frequent urination from prostatic hypertrophy or urethral stricture, on the other hand, may be quite painless.

Frequency of urination, with or without painful sensations, may be induced by affections of adjacent organs, especially the rectum and the uterus, while the urinary tract itself remains perfectly normal.

It should be ascertained whether an observed frequency of micturition is as pronounced at night as by day. If it persist at night, causing the patient to rise several times to void the urine, the fact constitutes presumptive evidence against the presence of calculus in the bladder, and directs attention especially to the condition of the prostate and urethra; for prostatic hypertrophy, chronic prostatitis, and urethral stricture are often productive of this symptom. It is also noteworthy that the polyuria attending cirrhosis of the kidneys is often more pronounced at night than by day; the patient actually secretes more urine during the hours of repose than in the waking condition, and is compelled to empty the bladder at shorter intervals by night than by day.

Another important subject for inquiry is whether or not *the desire to urinate occurs suddenly* as well as frequently. A patient often states spontaneously, as a prominent feature of his disorder, that he experiences suddenly an urgent desire to empty the bladder, so imperious as to brook no delay. This is especially characteristic of prostatic affections as distinguished from those of the kidney; it is also witnessed in functional disorders—from masturbation or venereal excess—of the genital organs, as well as in cases of irritability of the bladder from affections of the female genitals or of the rectum.

Pain upon micturition is a symptom of various affections of the urinary as well as of other organs. It should be ascertained, if pain be experienced, in what part of the urinary tract as well as at what period of the act of micturition it is felt; also whether it exist between the acts.

A smarting, burning sensation may be felt at the neck of the bladder and along the entire course of the urethra, from stricture, chronic prostatitis, or in consequence of extreme acidity or concentration of the urine. The same sensation, usually less pronounced, is a symptom in diabetes and hysteria. Attention has been already called to the fact that severe pain may be experienced over the kidney, along the course of the ureter, in the groin, and around the neck of the bladder, in cases where no

local lesion can be detected in any of these organs, in the genital organs or in the rectum. In such cases the possibility of a constitutional taint from malaria, syphilis, rheumatism, and gout should be inquired into.

In many affections of the kidney, pelvis, and ureter, pain is felt almost exclusively in the bladder and urethra, even though no local lesion exist in these parts. In these cases the pain is not especially aggravated during urination.

Pain which is felt only at the end of micturition is usually caused either by chronic prostatitis, cystitis, vesical calculus, or tumor; it may also be produced by stricture in the posterior urethra. The pain of chronic prostatitis is felt chiefly behind the symphysis and in the perineum, often extending along the urethra; the pain caused by a stone is felt chiefly at the neck of the bladder and at the end of the penis. In females a burning pain behind the symphysis is often due to displacements and disease of the uterus.

Pain felt around the neck of the bladder before and during micturition is a common symptom of acute and subacute cystitis.

Pain felt at some spot in the urethra during micturition is often occasioned by a stricture, the urethra behind the obstruction being dilated by the urine; even a slight contraction of the channel may produce it. In cases of bladder tumors, the pain (if any be felt) is usually aggravated during and after micturition, but often exists also in the intervals between the acts.

Pain felt especially in the perineum is caused by irritation of the prostate or of the bladder neck by inflammation, calculus, tumor, etc.

The condition of the urine may be made the subject of inquiry; whether or not habitual turbidity, high color, peculiar odor, or other characteristic have been noticed, and whether there has been at any time a pronounced sediment.

The admixture of blood with the urine constitutes an important feature of the case. The patient's statements in regard to this point are often incorrect; for a small quantity of blood is not recognized by the naked eye, and on the other hand he may mistake for blood an intense color observed in highly concentrated urine, or the bright red hue which is communicated to alkaline urine by certain vegetable articles used for food and medicine, notably rhubarb. If he have noticed what he regards as blood in the urine, it should be ascertained whether the blood preceded, accompanied, or followed the stream. The appearance of a few drops of blood at the end of urination is in the majority of cases due to prostatitis; it may occur in the course of a gonorrhœa from simple congestion of the mucous membrane of the pendulous urethra, without involving the prostate; it may also be produced by a polyp or urethral stricture. In cases of vesical calculus or neoplasm the blood sometimes appears toward the end of urination only, but is usually mixed with the stream. Blood which had been intimately mixed with urine for some time before voiding—as happens when it escapes from the kidney or the pelvis—frequently gives to the urine a dark brown or black color, which is not recognized by the patient as due to the presence of blood.

The manner of urination often furnishes information of value; it may be desirable to have the patient urinate in the physician's presence. It may be noticed that he handles the parts carefully, perhaps that he keeps the perineum enveloped in extra clothing—features especially characteristic of prostatic disease. The promptness with which the bladder obeys the impulse to evacuate the urine, the character of the stream, a possible

jerky irregularity of urination, and more or less dribbling at the end, should be noticed. Many patients, especially, though not exclusively, those affected with genital disorders, find unusual difficulty in urinating in the presence of a second person; hence we are sometimes compelled to rely upon their statements as to the manner of urination.

An irregular, jerky stream, appearing somewhat tardily in response to the voluntary impulse to urinate, is often seen in nervous young men, especially those who have been addicted to masturbation. In these cases there is frequently some dribbling at the end of urination or even some minutes after the act is apparently completed; the stream is usually small. These phenomena appear to be due to spasmodic contraction of the urethral muscles, they are also caused by stricture of the urethra.

A full stream which falls abruptly from the meatus is often seen in cases of prostatic hypertrophy, and may be an important point in diagnosis in those cases in which the hypertrophy affects only the so-called middle lobe and is not perceptible through the rectum; the same phenomenon may be caused by a stricture of large calibre in the posterior urethra. Some authors assert that the existence and location of a stricture can be somewhat definitely recognized by characteristics of the stream. Thus Dittel says that if the stream be thin and dropping there is usually a narrow stricture in the posterior portion of the urethra; if thin, with short bow and considerable speed, the stricture is narrow, forward, and rather long; if the stream be broken, the opening is not central.

Disease of the genitial organs also may induce the most diverse symptoms—disturbances of the cerebral functions, special senses, stomach, heart, peripheral nerves, as well as of the sexual and urinary functions. While it would be in many cases indelicate and impertinent to inquire minutely into the state of the sexual organs, yet a general question concerning them is rarely out of place; and it often happens that the patient is anxiously waiting and hoping that the physician will break the ice upon this subject. If some obscure affection of the urethra, bladder, or nervous system seem to exist, the patient should be discreetly questioned as to his sexual habits and functions: the extent of his venereal indulgence, past and present, his virility, etc. Many patients are evidently much relieved when an opportunity for discussing the subject is thrust upon them by the physician's question; for, while some men, alarmed by frequent pollutions or other genital abnormality, spontaneously direct the physician's attention to such symptoms, many others, even though believing or suspecting that their present symptoms are produced by sexual sins, are restrained by pride and shame from mentioning the embarrassing subject; and unless encouraged and directly questioned, they omit entirely or merely hint at those symptoms, however important in their own minds, which they believe to be associated with sexual abuses. Other patients are really ignorant that the annoying headache, affection of the eye, palpitation of the heart, or indigestion of which they may complain, are intimately associated with sexual excesses, etc., and therefore make no reference to these habits.

The manner of ejaculation is occasionally a proper subject for inquiry; it is precipitate and often feeble in consequence of venereal excesses; it is sometimes painful in cases of chronic prostatitis or urethral stricture (of which it may be one of the earliest symptoms); and it is sometimes lacking. An examination of the semen with the microscope is often absolutely necessary.

Examination of the External Organs.

The eye and the hand furnish important information, positive or negative, as to the nature of a difficulty in the urinary or genital organs. The meatus urinarius, the glans, and the prepuce should be carefully examined; a contracted or pouting meatus, an elongated prepuce, a tight phimosis, the accumulation of smegma behind the corona glandis, may constitute the key to a serious difficulty, and are especially to be looked for in cases of neuroses of the urinary or genital organs, such as irritability of the bladder, pain around the prostate, etc. The influence of such factors in prolonging these complaints is especially great in those who have suffered or are suffering from gonorrhœa. In cases of acute gonorrhœa, the division of a narrow meatus is effectual in shortening the duration of the discharge as well as in diminishing the sufferings of the patient. Sometimes a thin fold of mucous membrane conceals a pocket just behind the lower commissure, the division of which, like the division of a narrow meatus, may relieve obscure symptoms referred to bladder and urethra.

The condition of the scrotum and inguinal canal should be observed, the possible presence of varicocele, hydrocele, hardness and thickening of the epididymis and of the spermatic cord be noted. The spasmodic activity of the cremasters, as shown in the constant movements of the testicles, is especially frequent in the subjects of functional or neurotic difficulties of the genital and urinary organs. By some German surgeons this constant movement or "hodentanz" is regarded as characteristic of habitual masturbation. The constant presence of moisture at the meatus the "weeping penis," coldness of the penis, clamminess of the scrotum, are occasional symptoms in cases of similar origin. A slight gleety discharge may proceed from stricture (most frequent), from chronic prostatitis, or simple prostatic hypertrophy; or it may be seminal fluid (true spermatorrhœa being more frequent than is generally supposed).

Excessive masturbation frequently, though by no means invariably, produces certain changes in the genital organs recognizable by the eye. The penis appears elongated; the glans is disproportionately large; the mucous membrane covering it and the post-coronal furrow is thickened, resembling the cutaneous surface; the veins of the organ become enlarged and tortuous; sometimes the organ appears unnaturally cold, and the lips of the meatus are constantly wet. The scrotum is elongated, the testicles often tender and sometimes remarkably small and soft. The veins of the spermatic cord are frequently varicose.

In the female elongation of the clitoris and of the labia minora, hypertrophy and wrinkling of the prepuce, are found as the result of masturbation; the mucous membrane of the vagina is extremely hard and resisting, and the calibre of the canal frequently diminished in girls who practice this habit; an increased redness and secretion at the vaginal orifice may also be found.

If an inspection of the female genitals be made, the urethral orifice should be carefully observed. Small, but very painful vascular polyps are sometimes detected; the follicles at the lower border of the meatus sometimes furnish a chronic semi-purulent discharge, which is presumed to proceed from some other source; sharply-defined ulcers just within the urethral orifice are often found in cases of tuberculosis of the urinary or genital organs.

The glands in the groins should be examined; their enlargement may

furnish a clue to some obscure disorder. The possible dependence of urinary symptoms upon hæmorrhoids, fissures or ulceration of the anus and rectum, ascarides, etc., should be remembered and investigated. In the female a vaginal examination may reveal such a condition of the uterus and of the perimetritic tissue as suffices to explain symptoms referred to the urinary organs.

Examination per Rectum.

The introduction of the finger into the rectum often affords information which can be acquired in no other way. By means of it the membranous portion of the urethra, the prostate and neck of the bladder and the seminal vesicles are rendered accessible to the finger.

For this examination the patient is placed upon the back ; the trousers should be slipped down to the knees, a small cushion placed under the sacrum, the knees drawn up and the thighs separated. In special cases it may be desirable to have the patient lie upon his side, the knees drawn up toward the abdomen and the buttocks projecting over the edge of the table or bed. Otis adopts a different position. He says : "This examination will be most conveniently and efficiently made, not in the ordinary way by placing the patient on his back and inserting the finger between his thighs, but seated in a chair you direct him to stand squarely with his back presenting; have him drop his pantaloons and drawers, and with his knees straight bend forward at a right angle." Aside from the indelicacy of this position it is open to the same objection as the position upon the side, namely, that it does not permit the simultaneous examination with the sound which is so often necessary. The patient's muscular contractions necessary to maintain this position are also a disadvantage.

After the patient has assumed the position described—upon his back with the hips elevated upon a cushion (an important item)—the forefinger of the appropriate hand, well oiled, is gently introduced. This procedure is decidedly unpleasant to the patient and is apt to be resisted by spasmodic contraction of the anal sphincters ; gentleness of manipulation occasions the least resistance and offers the surest means of overcoming it. If the exploring finger causes extreme pain or violent spasm of the sphincter, the anus should be inspected to determine the possible presence of lesions.

Just within the sphincter the finger distinguishes on the anterior wall of the rectum a cord about an inch long, the membranous urethra ; sometimes the posterior surface of the bulb also can be detected. In cases of stricture at this portion of the urethra, a thickening often of irregular shape but sometimes in the form of a ring can be recognized.

At the inner extremity of the membranous urethra there is felt the apex of the prostate gland, rapidily widening as the finger follows it up the rectum. The groove in the middle line, corresponding to the urethra, is usually felt distinctly ; and even in cases of prostatic hypertrophy the point of the catheter can be felt through this groove. The upper border of the prostate, when this is of normal size, can be readily reached by the point of the finger of ordinary length ; sometimes, indeed, the last phalanx can be flexed around the prostate. The sound introduced into the bladder is met by the finger above and behind the prostate. In those cases in which there occurs enlargement of the middle lobe only (which always lies posterior to and projecting above the vesicle orifice of the urethra) its ex-

istence can be often surmised by the feeling that something unusual is interposed between the finger in the rectum and the sound in the bladder. In a few cases it has been found possible to detect with considerable certainty a globular projection from this part of the prostate.

The normal prostate is of firm consistence, smooth and symmetrical. At either superior angle the finger can feel and follow the seminal vesicle which stretches upward along the posterior surface of the bladder.

Abnormalities of the prostate are indicated by deviations in its size, smoothness, symmetry, and sensibility

A decrease in the *size* of the organ, atrophy, is not infrequent in advanced age and occurs in earlier life as the result of gonorrhœa and consequent prostatic inflammation. Enlargement of the gland may be the result of inflammation or of simple hypertrophy; in either case there is usually a symmetrical increase in size, the surface remaining smooth. The acute inflammatory enlargement is indicated by extreme heat and tenderness and by the projection of the prostate downward over the membranous urethra and backward encroaching upon the rectum. In cases of simple hypertrophy the upper border of the gland is often beyond the reach of the finger; in other instances this border can be detected on either side but is prolonged in the median line into an indefinable projection, often indicating an enlargement of the middle lobe. Firm pressure upon the abdominal wall above the symphysis may, by forcing the neck of the bladder somewhat lower in the pelvis, make the prostate more accessible to the finger in the rectum.

A lack of symmetry in the prostate may depend upon enlargement of one lobe or atrophy of the other; the latter condition is found after gonorrhœa and prostatitis. Enlargement of one lobe occurs in cases of tuberculosis, as well as in simple hypertrophy.

The consistence of the gland varies in different conditions. In cases of simple hypertrophy the prostatic tissue is unusually firm; enlargement from chronic inflammation is softer; in acute inflammation it has a soft, doughy feeling. In cases of abscess fluctuation can often be detected; in some instances prostatic concretions, lying in the distended prostatic follicles close to the rectum, have been recognized.

The smoothness of the surface is also to be noted. The presence of small hard nodules raised above the general surface is especially frequent in cases of tuberculosis of the gland; they are also found in that rare condition, malignant disease of the prostate.

The sensitiveness of the prostate is much increased in all inflammatory conditions, including the tuberculous; pressure from the rectum, like the passage of the sound through the prostatic urethra, occasions extreme pain in cases of chronic prostatitis, of habitual masturbation, and of sexual excess.

The examination of the gland per rectum is often followed by the appearance at the meatus of a milky or glairy fluid, which should be at once inspected through the microscope. It may be urethral or prostatic secretion, gleet, or semen, and should never be dismissed as simple "prostatorrhœa." If there be no history of gonorrhœa, and no prostatic hypertrophy, this fluid usually indicates habitual masturbation or excessive venery.

The exploration of the seminal vesicles is limited to an examination as to their size, consistence, and sensitiveness. In cases of chronic prostatitis these glands are often quite sensitive and distended in consequence of the occlusion of the ejaculatory ducts by the swelling of the prostate; a simi-

lar condition is sometimes detected as the result of stricture. This distention of the seminal vesicles may be extreme and may occasion the patient much discomfort, both local and general. It is observed in continent individuals, especially those who have suddenly discontinued a habitual sexual indulgence (*e. g.*, widowers); in such persons the unusual rarity of ejaculation may occasion distention of the vesicles, often with unpleasant sensations, irritability of the bladder, and nocturnal pollutions.

In some instances the ejaculatory duct is obstructed by concretions formed in the seminal vesicle; there results a distention of this vesicle and perhaps of the adjacent prostate. Gentle pressure with the finger may serve to dislodge the seminal concretions and reopen the duct. In one case reported, a man fifty-five years old, the right lobe of the prostate was much enlarged, projecting both into the rectum and the bladder; the tumor was quite tender upon pressure. Frequent and painful urination, the pain being felt especially toward the close of the act; the appearance of a few drops of blood at the end of micturition; dull pain in the perineum, often extending along the urethra to the meatus; all these symptoms taken in connection with the condition of the prostate, led to a diagnosis of tuberculosis of the gland. At a subsequent examination, pressure upon the enlarged prostate between the finger in the rectum and a sound in the bladder, caused a gush of whitish matter from the meatus in which small clumps of curdy appearance were seen; the fluid contained spermatozoa. The tumor of the prostate and all the unpleasant symptoms immediately disappeared.

CHAPTER III.

THE SOUND AND CATHETER.

The introduction of instruments into the urethra may be undertaken for the purpose of exploring the urethra only, or the bladder also; in the former case, the instrument should not be made to enter the bladder nor always the prostatic urethra. The habit of passing a sound quite into the bladder, even though the urethra only is the subject of exploration, is not only useless, but may be productive of harm.

The exploration of the urethra aims to detect chiefly two possible abnormalities—*a constriction of its calibre*, and *hyperæsthesia*, local or general. The canal anterior to the triangular ligament (membranous portion) should be explored *with an acorn or bulbous sound* (Fig. 1); since for obvious rea-

Fig. 1.—Bulbous Sounds.

sons the withdrawal of such a bulb constitutes a far more delicate means for detecting and localizing a stricture (especially when slight) than the introduction of an ordinary conical or cylindrical sound. The latter instrument often enables the surgeon to affirm that a patient *has* a stricture; *it rarely, if ever, justifies him in asserting the entire absence of strictures.* If a No. 9 English sound meets a decided obstacle at some point in the pendulous urethra of an adult, there can be no doubt (excluding the presence of foreign bodies, false passages, etc.), that the urethra is strictured at that point; but the passage, without pronounced resistance, of a 9, 12, 15, or even 18 English sound does not prove the absence of a urethral constriction which may be sufficient to maintain a gleet or other morbid condition of the urinary or genital functions, for the normal urethral calibre in the adult is rarely less and usually more than 17 English (30 French); hence even a considerable constriction may oppose no resistance to a No. 12 or 15 sound. Moreover, a stricture may be so distensible and elastic (resilient) as to admit, without marked opposition, a conical sound whose diameter exceeds its own; yet upon the withdrawal of the sound it contracts again. While such strictures are found with especial frequency in old men, they are by no means limited to such patients; and they may escape detection entirely by the ordinary sound, and if detected cannot be definitely located. By the bulb, on the other hand, they are easily recognized and located.

The following unique case illustrates, with unusual force, the uselessness of the ordinary sounds in detecting any except comparatively small or rigid strictures: T. L——, commercial traveller, thirty-five years old, applied for relief from a gleet which had existed about eighteen months, following his third attack of gonorrhœa. He had been under treatment almost constantly by injections and sounds. To my proposition to explore the urethra for stricture, he replied that this would be unnecessary; that he had once had a stricture which had been dilated to No. 24; and that he was now passing every week a No. 24 sound. Supposing this to be a No. 24 French (13 English), I produced the instrument, remarking that its passage did not prove the absence of stricture. To my astonishment he replied that *his* No. 24 was "about five times as big as that." Having no 24 English at hand I produced a No. 22 and found that it passed into the bladder without any serious resistance. I then introduced a 36 French bulb, the withdrawal of which was opposed quite decidedly at two points two and one-half and three and one-quarter inches from the meatus, a resistance quite perceptible to the patient. With the urethrometer I found that the calibre of the urethra at these points was only thirty-three and thirty-one. Having ascertained by the endoscope that the mucous membrane behind and between the strictures, though congested, was free from large granulations, I advised dilating urethrotomy for the cure of the gleet. As the patient demurred to this I made daily applications with the endoscope for a week, without perceptibly diminishing the discharge. He then left town on business, but returned six weeks later and expressed his consent to the operation. It was performed without anæsthetic, an incision two inches long being made so as to include the tissues in front and behind as well as between the two strictures; the tissues were divided to 42 French, no division of the meatus being required. A No. 24 (English) was passed daily until the sixth day, when the patient again left the city, the discharge being then a mixture of serum and blood. Two months later he called to say that since the tenth day after the operation there had been absolutely no discharge—for the first time in nearly two years.

While I have repeatedly cured a gleet by the division of strictures admitting (and hence undetected by) sounds as large as 14, 16, and in one case 17 of the English scale, a stricture admitting a No. 22 English is, in my experience, wholly unique: it suggests a topic for reflection to those who are in the habit of asserting the absence of stricture if the urethra will admit a 15, 14, or even 12 English sound.

There are two reasons why so many strictures are overlooked; indeed, only the pronounced ones (those of small calibre) are recognized by the ordinary method. First the cylindrical sounds fail to detect a slight or a resilient stricture; second, the meatus, when of fair size, is tacitly regarded as the measure of the urethral calibre; for although this relation of the meatus to the urethral calibre is not formulated as a distinct proposition, yet it is held in practice by nearly all surgeons who use only the ordinary sounds. For they rarely deem it necessary to enlarge a fair-sized meatus in "sounding for stricture," though just why the meatus is regarded as an index to the dimensions of the urethra, does not appear; indeed, we would expect that the meatus, like the mouth of every other pipe designed by nature or art to throw a stream, would be smaller than the channel behind it; and this is found to be true by actual measurements.

Many excellent surgeons decline to regard as a stricture anything which which will admit a No. 12 English sound; and in this they follow

no less an authority than Sir Henry Thompson,[1] who says: "If No. 10 or 11 of our scale goes easily—above all, if it is withdrawn without being held and slides out with perfect facility, take my word for it he has no stricture." He inveighs against the idea that the average urethral calibre should be greater than No. 11 or 12 of the English scale, and regards cylindrical bougies as adequate instruments for the detection of stricture. It will be remembered that this distinguished surgeon has always been averse to the introduction of large instruments into the urethra; it was only after long and bitter opposition that he admitted (very reluctantly) that the average urethra is sufficiently capacious to receive the large evacuating catheter (26 to 30 French), by the use of which Bigelow accomplished lithotrity at one sitting. These gentlemen do not deny the existence of urethral contractions larger than the meatus or than a No. 11 sound; but merely assert that such contractions are of no practical consequence, because devoid of morbid influence. The test must consist in the removal of such strictures in cases of gleet, urethral spasm, neuralgia, etc., where no other apparent cause can be found; and this test, made by numerous competent surgeons, has shown that slight strictures which admit a No. 11, 12, 15, or even larger sounds, are sometimes sufficient to maintain a gleet or vesical neuralgia, which ceases upon the removal of the urethral constriction. If surgeons who deny or ignore this could be persuaded to make this test in proper cases, their opinions would be entitled to greater consideration.

The detection of a slight stricture is one item; the interpretation of its morbid influence is another. The fact that many an obstinate and intractable gleet has been promptly cured by the division of slight strictures has led certain enthusiastic surgeons into a habit of ascribing nearly all obscure and obstinate genito-urinary complaints to such strictures; as a consequence there has been a somewhat promiscuous and often injudicious performance of urethrotomy. The numerous failures to relieve by this method morbid conditions produced by other causes, has brought unmerited discredit and distrust upon the whole subject. Even a gleet which is usually (though not always, as Otis insists) dependent upon stricture, may persist after the removal of all urethral contractions, however slight, and yield only to local applications.

The use of the bulbous sound in detecting strictures is restricted by the fact that the meatus is usually smaller than the general urethral channel; hence many slight constrictions (larger than the meatus) are not recognized. This restriction could of course be removed by division of the meatus; but this measure, so harsh and often unjustifiable, is never necessary—thanks to Dr. Otis' ingenuity in devising the urethrometer. This instrument is practically a dilatable bulbous sound which can be introduced closed through even a narrow meatus, and then expanded to any desired diameter in the more capacious urethra.

For detecting contractions of the cavernous urethra, therefore, bulbous sounds (or the urethrometer) should always be employed. The largest which can easily pass the meatus is first introduced; if this meet a decided impediment, smaller bulbs are substituted until the obstacle is passed; on withdrawing the instrument the abrupt shoulder is first arrested by, and then, upon slight traction, jumps over the stricture, communicating thereby a distinct sensation to patient as well as surgeon. The grasp of a spasmodic contraction of the urethral muscles (which is more

[1] Diseases of the Urinary Organs, 1882, p. 18.

frequently aroused by a bulbous than by a cylindrical sound) is continuous for several minutes, and gives an entirely different sensation.

Hyperæsthesia of the urethra, whether general or localized in spots, is also readily detected by the bulbous sound; but since this instrument may cause some pain even in a normal urethra, the discovery of sensitive spots should be confirmed by the introduction of a cylindrical sound; the bulb should, moreover, never be introduced into the prostatic urethra, because this portion of the channel is normally very sensitive, and is practically always free from strictures. Even the membranous urethra should not be invaded by a large bulb; for in passing the triangular ligament the instrument often causes pain and bleeding; and it may be tightly grasped and firmly held behind the ligament.

The selection of the instrument for exploring the bladder is naturally dependent upon the supposed condition of the parts to be explored, and upon the object to be attained. Thus in old men with prostatic hypertrophy the neck of the bladder is elevated and the prostatic urethra long; hence a catheter, to reach the bladder, must be longer than usual, and possess an extremely long curve. In children, too, the neck of the bladder is higher than in adults, and the beak of the instrument must be made correspondingly long. For the exploration of the bladder, where no hypertrophy of the prostate exists, an instrument with an abrupt curve and short beak, capable of being rotated in the bladder, is required.

Metallic instruments designed for introduction into the bladder should, generally speaking, be made to conform to the natural curvature of the less movable portion of the urethra, the sub-pubic curve. This curve of the urethra, traced along its upper wall, begins just in front of the pubic bones at the insertion of the suspensory ligament of the penis, rather more than an inch anterior to the bulb; thence it descends (when the body is erect) attaining its lowest point at the anterior layer of the triangular ligament; it then ascends through the membranous and prostatic portion. The posterior end lies somewhat higher than the anterior. This curve constitutes the arc of a circle three and a quarter inches in diameter (Thompson); the chord of the arc runs almost perpendicular to the axis of the symphysis, but is inclined slightly upward from before backward.

The urethra is attached at three points in this curve—the suspensory ligament, the triangular ligament, and the pubo-prostatic ligament; these permit, nevertheless, a certain amount of variation in the curvature of the urethra, so that even a straight instrument can be introduced into the bladder. Advantage is taken of this fact in the construction of sounds, lithotrites, etc.; a short abrupt curve facilitates the entrance of the instrument into the bladder, after which it can be pushed on until the entire beak is contained in the cavity of this organ, the straight shaft occupying the urethra. Indeed an instrument which has no curve, but is straight throughout its entire length, can be by careful manipulation introduced into the bladder without injury.

The ordinary metallic catheters and sounds should be constructed so as to conform to the curve of the urethra as measured by Thompson, namely, that this curve constitutes the arc of a circle whose radius is one and five-eighths inch, the chord of the arc measuring two and three-quarter inches. The catheter should have a curve corresponding to one-fourth (90 degrees) of this circumference; the sound should be shorter, and is usually made with a curvature covering about 60 degrees of this same circumference. When the longer of these two instruments is used, the point arrives in the prostatic sinus when the shaft rests at an angle of

45 degrees with the horizon (the patient lying upon his back); the point of the shorter instrument rests in the membranous urethra when its shaft is inclined at the same angle.

The sounds and catheters in general use are often of faulty curvature, especially at the extremity; this is too long or too straight. Many of the difficulties of catheterization arise entirely from these instrumental defects. Except in especial cases already mentioned, the catheter should not comprise more than one-fourth of the circumference; indeed, a shorter instrument is often preferable. But in any case the end of the catheter should be so curved that the axis of its extremity forms a right angle with the axis of the shaft; in many instruments it will be noticed that the angle formed by these two axes is decidedly acute. The point of the instrument should be not more than one and three-quarter inch from the axis of the shaft; and if it be only one and one-half or even one and one-fourth inch, it is more easily managed, and often quite as serviceable. The sound is made with a shorter beak so that the entire curved portion can be introduced and revolved within the bladder.

The introduction of the catheter should be undertaken only when the patient occupies the recumbent posture. The clothing is removed sufficiently to afford the surgeon free access to the perineum and external genitals, and to permit the necessary depression of the shaft between the thighs. The operator ordinarily stands upon the left side of the patient, though he must be able to catheterize from either side. Since a rectal exploration is often necessary while the instrument rests in the bladder, it is convenient to have the patient's hips elevated upon a small cushion before introducing the catheter.

The instrument, previously warmed and oiled, is held lightly between the thumb and first two fingers of the right hand, its shaft placed horizontally over the left groin. The left hand grasps the penis, the thumb and forefinger applied so as to retract the prepuce. The organ is raised above the groin, the point of the catheter is then introduced into the urethra, and the entire instrument is slid bodily downward (toward the knees), the shaft still retaining the horizontal position. Meanwhile the penis is drawn over the instrument with the left hand. When the point has penetrated to the suspensory ligament—about as far as it will enter without force—the shaft is carried from the groin to the median line over the abdomen; then, while the scrotum is grasped and elevated toward the pubes, the upper end of the catheter is gently raised until the shaft assumes the vertical position, a movement which should be readily accomplished without force by a single finger. The forefinger of the right hand is now placed over the open end of the catheter, which is then carried downward into the space between the thighs; during this movement slight pressure may be made, so as to cause the point of the instrument to progress.

If there be no abnormality of the urethra, the introduction of the catheter is usually effected in this way without any difficulty; the impediments which an experienced hand meets are often due to his own anxiety, which induces him to grasp the instrument firmly and employ force in its introduction. No force is required or permitted; skill in catheterization is exhibited not in overcoming but in avoiding obstacles.

Success will be favored by selecting a large instrument, not less than No. 9 or 10 English, unless some abnormal impediment, such as a stricture, exists. Since the meatus is usually the narrowest part of the canal, the surgeon will rarely make a mistake in selecting the largest instrument admitted by the orifice.

The obstacles which may oppose the entrance of the catheter into the normal urethra are the following:

1. Contracted meatus.

2. The large follicle situated on the upper wall of the urethra an inch or more from the meatus, known as the "lacuna magna." This causes no difficulty if a large catheter be used as directed, though in the introduction of small conical catheters and bougies, it is to be avoided by keeping the point of the instrument on the floor of the urethra for about two inches from the meatus.

3. The symphysis impedes the progress of the catheter in case its point is permitted to project upward too soon. This is apt to happen when the shaft of the catheter is revolved to the median line over the abdomen in corpulent persons; to avoid it the point is depressed.

4. *The sinus of the bulb* occasions the beginner more difficulty than all the other normal impediments together. For since the urethra is here much larger than in the membranous portion adjoining it, and is moreover easily distensible there occurs a saccular dilatation of the floor of the urethra just anterior to the triangular ligament. The point of the catheter is apt to follow the floor of the canal and be stopped by the ligament. In the effort to overcome this obstruction, the point is sometimes forced through the wall of the urethra, which is here unusually delicate and easily lacerated. The difficulty at this point is overcome by keeping the point of the instrument against the roof of the urethra, and by depressing the outer extremity of the catheter, whereby the point is raised and guided into the opening in the ligament which contains the membranous urethra. The chances of avoiding this obstacle are increased by gentle traction of the penis, whereby the saccular enlargement of the bulbous urethra is obliterated by the stretching of its floor. It is sometimes necessary to place a finger on the perineum or in the rectum, and thus elevate the catheter and guide it through the triangular ligament.

5. Spasmodic contraction of the membranous urethra occasionally opposes the entrance of the catheter. It is usually overcome without difficulty by steady pressure with the point of the instrument for a few minutes. It is sometimes difficult to determine whether the obstruction at this point is a spasmodic contraction, an organic stricture, or the triangular ligament. In the latter case the point of the instrument is freely movable in any except the outward direction; while if the instrument be engaged in a stricture, either organic or spasmodic, it is perceptibly grasped and retained. The grasp of a muscular contraction is often plainly distinguished from that of an organic stricture; yet it is certain that the two are sometimes confounded, misleading the surgeon into a diagnosis of organic stricture where nothing but a spasm of the membranous urethra exists. Dr. Otis thinks that this often occurs; he says: "Deep organic urethral stricture is often simulated by muscular spasm. *The great proportion of cases treated by gradual dilatation, are treated for deep stricture which does not exist.*"

Such a case—in which systematic dilatation of a spasmodic stricture was undertaken in the belief that it was an organic constriction—has not fallen under my observation. Yet I recently saw a case in which external urethrotomy was proposed for the relief of a supposed organic stricture. The patient was a man of forty, who applied to a prominent local surgeon at a public clinic for relief from frequency and pain in urination. He stated that he had had a gonorrhœa (his first attack) six months previously; that a gleet had persisted until within a month; he had used injections and had finally succeeded in stopping the discharge. Since the cessation

of the gleet urination had been frequent, compelling him to rise several times during the night, and had been accompanied with much pain. The surgeon, suspecting stricture, attempted to introduce a large steel sound; this was arrested in the bulbous portion. Successively smaller instruments were introduced, until finally filiform bougies were employed. All were arrested at about the same point; the use of the bougies occasioned the patient much pain, and was followed by the appearance of some blood at the meatus. A diagnosis of tight stricture was made, and the patient advised that an operation would probably be necessary. A few hours later he applied to me. I found that a No. 12 English was arrested at the bulbo-membranous junction. Suspecting a spasmodic stricture, I desisted from further efforts, and advised the patient to permit no further mechanical interference for three days, in order to allow the swelling and irritation to subside. At the end of the time specified he called again; a No. 12 was again arrested at the same point, but entered the bladder upon the exertion of gentle pressure. As the patient happened to have a large meatus, I introduced still larger sounds and found no difficulty in passing a No. 17 English into the bladder.

6. The prostatic urethra in its normal state contains no obstacles to the entrance of the catheter, though the passage of the instrument through it often occasions the patient some pain. A filiform bougie has occasionally entered the orifice of the sinus pocularis. In abnormal conditions of the prostate, however, this portion of the urethra may occasion the surgeon great difficulty and perplexity in the attempt to introduce the catheter. In prostatic hypertrophy the contained urethra may be much increased in length, so that the ordinary catheter is too short to reach the bladder; or it may deviate from its usual course, to one side or the other, forward or backward. If the middle lobe be enlarged the urethra may acquire an additional curvature before entering the bladder. Most of these conditions can be at least suspected by examination per rectum; but some of them, especially those dependent upon enlargement of the middle lobe, may escape detection by rectal exploration, and be suspected only from the difficulty experienced in the introduction of the catheter. It is also to be remembered that the prostatic urethra may be so dilated as to contain considerable urine; the escape of this urine may deceive the surgeon into the belief that his instrument has reached the bladder.

7. If the penis be not stretched over the catheter, the point of the instrument may be arrested by a projecting fold of mucous membrane any where in the pendulous portion.

Whenever the point of the catheter meets an obstruction the instrument should be withdrawn half an inch or more and advanced again with its point in a slightly different direction. In case there is a probability that a false passage exists, the point of the instrument should be guided along one or the other side of the urethra, since the false passage is probably on the upper or lower surface. It is well to bear in mind also the fact that an organic stricture may exist even though there be no history of gonorrhœa or injury; since it may result from masturbation or congenital formation.

Dangers of Catheterism.

These are but few and insignificant if the urinary apparatus be normal, but are numerous and perilous if abnormal conditions of the urethra or bladder exist. Primary disease of the kidneys constitutes no objection to the use of the catheter; it is only in those renal affections which result

from disease in the lower portion of the urinary channel that disaster to the kidneys results from catheterism.

Before introducing a catheter it is important to ascertain, as definitely as possible, the condition of the urethra, the prostate, and the bladder. The possible existence of a stricture or of a false passage from previous instrumental examinations; hypertrophy of the prostate; paresis, atony, or hypertrophy of the bladder; contraction of the meatus and phimosis, should all be the subject of inquiry, for if none of these exist, the dexterous introduction of the catheter can scarcely occasion any evil; while in the presence of one or more of these conditions, even skilful catheterism may occasion serious results.

The injuries which may follow the passage of the catheter are either direct or indirect. The former are comprised almost entirely in possible mechanical injury to the urethra, and occur only when an undue amount of force is used. They are therefore especially frequent in those cases in which the entrance of the instrument is opposed by a stricture, by entanglement in a false passage, or by awkward manipulation in the bulbous urethra. Such injury is indicated immediately by pain and hemorrhage, and subsequently perhaps by a chill and fever. These symptoms, caused by laceration of the urethra, usually occur within three to five hours after the introduction of the instrument.

The indirect injury which may be caused by the introduction of the catheter, even when skilfully performed, occurs especially when the bladder is unable to evacuate itself completely. This is usually the result of a mechanical impediment in the urinary channel, particularly prostatic hypertrophy or stricture; hence it is especially in patients afflicted with one or the other of these conditions that the use of the instrument is attended with serious consequences. In some few cases faintness and even syncope have been known to follow the introduction of a catheter into an acutely distended bladder, the distention resulting simply from voluntary retention of urine. In the greater number of cases, however, the disastrous results of catheterization have occurred in individuals suffering from stricture, prostatic hypertrophy, or other mechanical impediment, causing an habitual distention of the bladder in consequence of its inability entirely to overcome the existing impediment. An inquiry into such cases shows that there has long existed considerable difficulty in urination; that in consequence of excesses in eating or drinking, exposure to cold or enforced voluntary retention of urine, there has occurred such an inability to evacuate the bladder as has required the services of a physician. The catheter is introduced, usually without great difficulty; a large amount of urine is withdrawn; the patient experiences no ill results until two or three days have passed, when the first symptoms of a condition resembling typhoid fever exhibit themselves.

In these cases the result of catheterization is attributable not to any mechanical injury of the urethra, nor to any hypothetical reflex nervous influence, etc., but simply to the removal of an accustomed pressure from the walls of the bladder, ureters, pelves, and urinary tubules. For the impediment which has resulted in the inability of the bladder to evacuate itself—the stricture or prostatic hypertrophy, for instance—has resulted first, in the habitual retention of more or less urine, and second, in a hypertrophy of the muscular fibres of the bladder which give to that organ more than its normal firmness. If the impediment have long existed, a similar dilatation will be found to have affected the ureters, the pelves of the kidneys, and even the urinary tubules. The introduction of the cathe-

ter, by withdrawing entirely the urine habitually retained in the bladder (and perhaps ureters and pelves), causes extreme venous congestion of the mucous membrane in the bladder at least, and in those other portions of the urinary tract which have been distended. In many cases this congestion affects not only the superficial blood-vessels of the mucous membrane but also those lying in the parenchyma of the bladder. The result of this congestion—which the Germans call *hyperæmia ex vacuo*, or negative pressure—depends upon its degree, that is, upon the amount of residual urine habitually present in the bladder as well as upon the degree of hypertrophy, and hence inflexibility, which the muscular walls of the organ have attained. In those cases in which the bladder has suffered but little change, the hyperæmia is usually of slight degree and temporary duration ; the patient has a chill, some fever and an escape of blood with the urine—the latter due not to mechanical injury of the mucous membrane but simply to the extravasation of blood from the congested vessels. In severer cases this congestion is the prelude to an inflammation, which may affect only the mucous membrane, but often involves the entire tissue of the bladder, resulting in an acute parenchymatous cystitis and even pericystitis ; the bladder-wall becomes swollen and softened and exhibits miliary abscesses ; suppuration may occur also in the connective tissue around the bladder and rectum. The urine often has a fecal odor.

In severer cases, those in which the ureters and the kidneys have suffered from the habitual retention of urine, the phenomena of vesical irritation and inflammation are often masked under the more alarming signs of renal disturbance. As already mentioned, hemorrhage into the tubules of the kidney frequently follows the introduction of the catheter in the class of cases under discussion ; this hemorrhage, like that from the vesical mucous membrane, is the result of the intense congestion consequent upon the sudden removal of the urine which habitually distends the tubules. A high degree of this congestion, produced in cases of great distention and hypertrophy of the bladder, occasions complete anuria.

The experience of every surgeon furnishes instances in which the simple skilful introduction of a catheter has been followed by more or less unpleasant results, ranging in severity from slight chill and fever, to a general inflammation of the urinary tract—cystitis, pyelitis, nephritis—or to fatal anuria. The literature of this class of diseases abounds in similar instances which have happened even to the most distinguished and skilful of modern surgeons ; and in warnings as to the possible disasters consequent upon the introduction of an instrument into the bladder. Yet but few if any of our standard text-books upon the subject make a very clear and decisive distinction between those cases which may be catheterized without danger, and those in which disaster may be apprehended. In nearly all cases the danger is ascribed to the *introduction of the instrument*, rather than to the *evacuation of residual urine*—the real element of peril. Thus Coulson says,[1] "cystitis of a severe and even fatal kind has been known to follow the passage of a catheter or sound. It is only reasonable to assume that in the majority of such cases an undue amount of violence was the cause of the mischief." Again "it seems probable that by reflex action the passage of an instrument along the urethra induces, under certain circumstances, a disturbance in the circulation of the kidney, or interferes in some manner with its function." Sir Henry Thompson[2] in

[1] Diseases of the Bladder and Prostate Gland, sixth edition, 1881, p. 37.
[2] Clinical Lectures on Diseases of the Urinary Organs, 1882, p. 56.

speaking of the introduction of the catheter in the treatment of cases of prostatic hypertrophy, refers to the unpleasant consequences often experienced, and suggests, somewhat vaguely, a plan for avoiding them, without hinting at the explanation. He says: "I revert to a fact already alluded to, which is one of considerable importance, that although the urine may have been quite clear before the catheter was employed, yet in some instances, after its habitual use has been continued for a short period, the secretion becomes cloudy and the patient is feverish and unwell. A stage of constitutional derangement, more or less marked, has sometimes to be passed by those persons who, having long experienced difficulty, suddenly change from their usual mode of micturition to the artificial one. Sir Benjamin Brodie was the first to remark it, and in his valuable lectures called attention to the circumstance that patients might even sometimes gradually succumb with symptoms of low or irritative fever a few weeks after beginning to use the catheter." As to the cause of these phenomena he merely says: "If the patient has been in the habit of retaining perhaps a pint of urine or even more after he has made water, it is a serious change for the bladder to be suddenly and completely emptied two or three times a day; the organ soon becomes irritable, the urine is charged with pus, and the patient loses appetite, becomes feverish, and there is sometimes considerable danger to life."

A knowledge not only of the clinical fact but also of the anatomical conditions which explain it, is extremely important, for without it the surgeon who introduces the catheter is groping in the dark and liable to be overtaken in any case by a disaster which he is unable to explain or avert. Now these cases of prostatic hypertrophy, stricture, and other impediments to the evacuation of urine, constitute a large proportion of the cases in which the catheter is required in treating the adult male. Hence the importance of ascertaining in every case in advance the presence or absence of such impediments and of the dilatation and hypertrophy of the bladder consequent upon them.

A comprehension of these anatomical relations suggests also the precautions to be adopted in treatment, precautions which are quite as necessary in evacuating the bladder for sudden retention as in cases of habitual catheterism. Since the ill effects are traceable to a "hyperæmia ex vacuo," a congestion in consequence of the removal of the accustomed pressure caused by residual urine, the first requisite in preventing these ills is, of course, precaution to avoid this congestion, that is, care not to empty the bladder completely. Sir Henry Thompson, speaking of the use of the catheter in prostatic hypertrophy says, "it is undesirable to empty the bladder completely on every occasion of catheterism during the first few days." It is, indeed, extremely desirable and absolutely essential for the patient's welfare that the bladder should *not be emptied completely at all* during the first few days. Without further discussion of this item of treatment here, it will suffice to say that whenever the catheter is to be introduced in cases of retention of urine in individuals who have stricture, enlarged prostate or other impediment which may be reasonably assumed to have caused dilatation of the bladder, care should be taken to evacuate not more than half of the urine, whose quantity can be estimated by palpation over the pubes and through the rectum, by percussion of the abdomen, etc. If this rule were generally observed, the introduction of the catheter would not be held responsible for nearly so many inexplicable and unforeseen disasters as is now the case; and instances of "urethral fever" would be less numerous.

The evil effects consequent upon the sudden and complete evacuation of an habitually dilated bladder are not confined to the use of the catheter and sound alone. Operations in the deep urethra or in the bladder, whereby long-standing impediments to the flow of urine are suddenly removed, are also fertile in producing cases of cystitis, pyelitis, and nephritis. The removal of a tight stricture in the posterior urethra by either cutting or rupture, the operation of lithotomy in elderly men, is more or less dangerous largely according to the condition of the bladder. Lithotomy is notoriously far safer in children than in adults, other things being equal; the greater safety lies evidently not in the operation itself—for the close proximity in the child of parts to be avoided increases the danger of accident from the knife—nor is it to be sought in the removal of the stone, for there is greater probability of bruising and crushing the parts in the child than in the adult. The reason for this greater safety lies largely in the fact that the child's bladder is free from other abnormalities than those caused by the presence of the stone itself; there is no prostatic hypertrophy, probably no dilatation and hypertrophy of the bladder, no dilatation of the pelvis and urinary tubules, conditions which are responsible for so much of the mortality following lithotomy in the adult. For it is well known that this mortality arises not from the injury inflicted by the knife in entering, nor by the stone in leaving the bladder, but from the cystitis, pericystitis, pyelitis, and nephritis which develop in the course of a week or two after the operation. Surgeons are in the habit of gauging the probabilities of success after lithotomy in an old man by the "condition of the kidneys;" the fact is that the condition of the kidney is, so far as it affects the result of the operation, dependent upon abnormality in the bladder or urethra; a primary disease of the kidney does not predispose to inflammatory reaction after lithotomy, provided the bladder is free from dilatation and hypertrophy.

Another possible danger in the use of the catheter is the introduction of materials into the bladder which may excite cystitis. Without discussing the nature of such materials, whether they be organized or unorganized substances, it remains an assured fact that cases of cystitis have been definitely traced to the use of unclean instruments. Nor is this surprising when we observe the almost universal practice of cleansing a catheter by simply wiping it on a towel or permitting a stream of water to run through and over it. That instruments should be rendered *surgically* clean is in these latter days axiomatic; the best means to this end is undoubtedly immersion in a weak (one part to 5,000) solution of corrosive sublimate in water. Carbolized oil or vaseline, frequently employed by surgeons, has absolutely no value for this purpose. As metallic instruments are rapidly corroded by the sublimate, they may be heated in an alcohol flame.

However desirable as a routine practice the cleansing of catheters and sounds by antiseptic agents may be, the neglect to do so is followed by serious results in comparatively rare cases; and these are cases in which the bladder habitually fails to expel its contents, and therefore always contains residual urine. The reason for this lies simply in the fact, experimentally as well as clinically demonstrated, that septic materials, organized as well as unorganized, gain no foothold on the mucous membrane of a healthy bladder. Putrid fluids, swarming with the bacteria of putrefaction, have been repeatedly injected into the bladders of dogs without causing the least observable pathological effect. For the bladder at its next contraction expels such fluids entirely, and until injured in some way affords no opportunity for the origin or development of a septic process. It is quite

otherwise, however, if, after the injection of the putrid fluids, the bladder is prevented from emptying itself, by tying a ligature around the penis for example. In this case, while the mucous membrane itself affords no opportunity for septic processes, the retained urine furnishes ample material for fermentation; as a result, the urine undergoes the ammoniacal change ordinarily exhibited outside of the body, and cystitis follows. A precisely analogous process occurs as the result of the introduction of an (surgically) unclean catheter into a human bladder which habitually retains more or less urine. While, therefore, such a catheter may be used with impunity in the great majority of individuals, its employment in cases of stricture, prostatic hypertrophy, paresis, and atony of the bladder, and other conditions in which residual urine is present, is often productive of cystitis.

Nor does the damage rest with a simple inflammation of the bladder. For, in the class of cases referred to, the impediment which causes first the dilatation of the bladder and habitual retention of urine in its cavity, may produce, sooner or later, an extension of this condition to the ureters and renal pelves, which then contain a certain amount of residual urine. Ammoniacal fermentation, originated in the bladder by an unclean catheter, extends of course to the urine contained in the ureters and pelves. In such cases pyelitis and suppurative nephritis follow rapidly upon the cystitis.

Epididymitis is an occasional result of the introduction of the catheter, rarely after the passage of the instrument only a few times, but frequently occurring sooner or later in those cases in which the habitual use of the catheter is rendered necessary by prostatic difficulty.

Acute prostatitis has in a few instances been occasioned by the introduction of catheters and sounds.

CHAPTER IV.

URETHRAL FEVER.

This term has been used to designate the various morbid phenomena which so often occur after operations upon the urethra and bladder. The name expresses the general understanding of surgeons with regard to it—that it is a reflex or nervous phenomenon due to contact of instruments with the extremely sensitive mucous membrane of the urethra. The fact that these symptoms occur without mechanical injury to the mucous membrane, may even follow the skilful and unopposed introduction of the catheter, has given rise to the hypothesis that the urethra is endowed with some peculiar sensibility not possessed by other mucous membranes, which can be called into action by simple contact of a smooth and soft catheter; and which, thus aroused, exerts an influence not only upon the organs in its immediate vicinity, but also upon the circulation through the kidneys and even upon the heart itself.

Thus Civiale, quoted by Otis, says: "Independent of its local sensitiveness, the urethra possesses another kind which may be termed sympathetic. When this sensitiveness is aggravated it may awaken sympathetic response in every organ and function of the body." Gross[1] says: "The urethra seems to possess some peculiar morbid sympathies, through which the introduction of the catheter is sometimes followed by unpleasant effects, as partial syncope, shock, epileptiform convulsions, and even death. These occurrences are most common in persons of a nervous, irritable temperament, or who have suffered from intermittent fever or lived in hot climates; and cannot always be prevented, however cautiously the operation may be performed. The sensibility of the urethra is very great, and hence it is not surprising that the contact of a bougie, however slight, should occasionally be followed by great pain in the parts, nervous prostration, and other disagreeable effects." Otis[2] remarks: "In persons of highly nervous temperament the predisposition to urethral fever is the rule, and any slight mechanical interference may give rise to it." Coulson[3] says: "The cause of the symptoms of urethral fever is very obscure, but it seems probable that by reflex action the passage of an instrument along the urethra induced under certain circumstances a disturbance in the circulation of the kidney or interference in some manner with its function. It was formerly supposed that the symptoms were due to absorption of urine from a wound or excoriation in the urinary passages, but on the one hand the rigor often occurs before any urine is passed, and on the other it is not found that rigors invariably follow lithotomy or internal or external urethrotomy, after all of which operations urine is more or less frequently in contact with a wounded surface of the urethra."

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[1] Diseases of the Urinary Organs, Third Edition, p. 127.
[2] Loc. cit., p. 467.
[3] Loc. cit., p. 39.

Sir Henry Thompson[1] says: "What is usually termed fever" (after lithotrity) "is a series of phenomena which denote a peculiar disturbance of the nervous system, the product of mechanical interference with the male urethra. Thus a slight over-dilatation of the canal with a bougie, and still more the occurrence there of some considerable lesion, may produce a febrile attack."

Nearly all authors agree with those quoted in ascribing urethral fever largely to an extreme sensibility of the urethra, in consequence of which, simple contact—which might be harmless in the case of other mucous membranes—may arouse constitutional reaction.

Many writers emphasize the necessity for an examination into the condition of the kidneys before undertaking any operation upon the urethra or bladder, as a precaution against serious "urethral fever." They recognize the fact that renal disease is often aggravated by such manipulations, but offer no better explanation than reflex action or the contact of urine with an abraded surface. Thus Otis,[2] in discussing urethral fever, says: "I hold that in cases of long-standing urethral trouble and in all elderly persons the passage of any instrument through the urethra into the bladder should never be attempted without a preliminary examination of the patient's urine to determine the state of the bladder and kidneys. It is not from the fact that urethral fever in such cases is more likely to occur and with possibly greater severity than in healthy persons that this predisposition is important, but because when it does occur the danger of the reflex irritation extending to the ureters and kidneys and inducing a suppression of urine, is greatly increased, and that suppression so induced is frequently and rapidly fatal." Van Buren and Keyes[3] say: "That all these disorders should depend upon the simple absorption of urine through an abraded surface is in the highest degree improbable. Other forces are at work, and these are probably shock and reflex action, suspending the function of the kidney, often already diseased. The condition of the urine also has much to do with the origin of urethral fever. It produces no effect in contact with a wounded surface when it is normal. When in ammoniacal fermentation it is undoubtedly capable, if absorbed, of occasioning septicæmic and pyæmic phenomena, and unfortunately in bladder and urethral disease the urine is very often more or less decomposed. The extent of the injury done is no index of the amount of fever that will follow. The gentle passage of a smooth sound may cause speedy death, while extensive wounds and lacerations of the canal are often absolutely innocuous, and that, too, where the urine is strongly alkaline."

It is evident, from a consideration of the cases recorded, that the term urethral fever comprises several distinct pathological processes; and it is equally evident, from the opinions advanced by experienced surgeons, that the intimate nature of these processes is generally unknown. Indeed Van Buren and Keyes frankly say (p. 45) "the uncertainty which surrounds that condition known as urethral fever has not yet been entirely cleared up." It is generally assumed that there is a reflex nervous action, originated by irritation of the urethra and reflected upon the renal circulation. This is of course pure hypothesis; there is in many cases no evidence of urethral irritation, while in many others in which extensive laceration occurs, no urethral fever or other evidence of reflex action follows. Moreover, in those instances in which an aggravation of renal disease follows the

[1] Loc. cit., p. 89. [2] Loc. cit., p. 467.
[3] Genito-Urinary Diseases, p. 46.

introduction of instruments into the urethra, there is no proof that the morbid changes observed in the kidney can be traced to the irritation, real or hypothetical, in the urethra.

If the clinical history and the post-mortem appearances be carefully investigated, it will be found that these cases may be divided into two general classes; first, those in which the use of instruments has occasioned demonstrable and direct lesions sufficient to explain the symptoms on anatomical grounds; and second, those in which no lesions are discoverable, and which are therefore explained by a hypothetical reflex nervous influence. The latter class is generally supposed to include by far the greater number of cases of urethral fever, but a careful consideration of the anatomical relations of the different organs composing the urinary tract, materially reduces the number of cases which cannot be explained upon anatomical grounds.

Lesions of the urethra or bladder, caused by the introduction of instruments, are held responsible for many cases of urethral fever. In some of these cases the wound undoubtedly becomes the starting-point for abscess formation, phlebitis, and pyæmia; but in most instances the lesion is slight, is indicated only by the escape of blood from the urethra, and is nevertheless followed by the severer as well as by the milder forms of urethral fever. In many of these cases there is no reason for ascribing the constitutional effect to the insignificant injury, *except that no other explanation is to be found.* All surgeons recognize the utter disproportion between such slight lesions and the severe symptoms which follow, and many attempt to explain the connection between the two by assuming that the passage of the urine over the lacerated surface, and not the laceration itself, causes the nervous reaction. This hypothesis is exploded by the simple fact that the chill and fever often occur before any urine has passed over the wounded surface. The suggestion that ammoniacal urine may, by simple contact with the abraded tissue, cause the chill and fever is opposed by the fact just mentioned, that this reaction occurs before contact with the urine has taken place; moreover, the urine is in many of these cases not ammoniacal; furthermore, such contact is in many other instances not followed by urethral fever.

The aggravation of pre-existing inflammation of the urinary organs is supposed to be induced by reflex action from the irritated urethra. Cystitis, pyelitis, and suppurative nephritis are frequently found post mortem after the introduction of a catheter or sound into the bladder, but that they are produced by reflex irritation has not been demonstrated.

Allowing the greatest possible latitude to these anatomical disturbances in the explanation of the abnormal phenomena which follow the introduction of the catheter or sound, as well as operations upon the deep urethra or bladder, there remain numerous cases, constituting the majority of those observed, which lie beyond the pale of such explanation; cases in which there is no evidence, during life or after death, of laceration of the urinary passages, or of pre-existing disease of the kidney. These cases comprise:

1. Instances in which chill, fever, and other signs of constitutional disturbance are exhibited for a few hours or days after the passage of an instrument in individuals whose urinary organs, including the kidneys, are apparently healthy.

2. Those in which the patient has long had an impediment in the evacuation of the urine—usually a stricture or prostatic enlargement—but no evidence of renal disease. Many of these cases terminate fatally, and the report of the autopsy records normal kidneys, *except that they are intensely congested.*

3. Those cases in which syncope, collapse, and even death follow immediately upon the evacuation of an over-distended bladder.

The explanations offered for these cases have been chiefly: (1) shock; (2) uræmic poisoning; (3) reflex action through the nervous system arising from local irritation by the presence of the instrument in the urinary canal.

If the term shock can be properly applied to any of these cases, it must certainly be restricted to those in which the sudden evacuation of an over-distended bladder—whether the distention be acute or chronic—is followed immediately by such failure of the heart as to cause faintness or even death. The well-known case quoted by Sir Henry Thompson is an illustration; in this instance "the old man was placed upright against a wall, the catheter introduced, and six pints of urine were withdrawn in full stream; but the water had no sooner ceased to flow than the patient fell dead at the surgeon's feet. Fatal syncope had taken place, doubtless in consequence of the rapid removal of so large a body which had previously pressed on the abdominal veins and viscera." Since effects precisely similar in kind, if not in degree, are familiarly known to follow the evacuation of large quantities of fluid from the abdominal cavity without any interference whatsoever with the urinary organs—as in cases of ascites and ovarian cysts—it is fair to assume that the depressing influence which causes the syncope in such cases of evacuation of the over-distended bladder, arises not from any peculiarity of the urinary organs, but simply from the general arterial anæmia caused by the sudden intense congestion of the abdominal vessels following the rapid removal of previous pressure.

Uræmic poisoning cannot be reasonably assumed to explain cases of sudden and immediate nervous disturbance after the use of the catheter, even though partial or complete anuria results; for the interval which must elapse before an accumulation of urinary ingredients in the system could manifest itself as uræmia is far greater than that which actually occurs in these cases.

Reflex action through the nervous system, originated by local irritation in the urinary channel, is the favorite hypothesis adopted for explaining urethral fever in the absence of anatomical appearances. This idea of "reflex action" is so vague and indefinite, so convenient and heretofore so entirely devoid of experimental proof or disproof, that it has been made a general scapegoat for excusing and explaining urethral fever and other complications of catheterism which could not be explained by direct and visible anatomical changes. Indeed, so simple and satisfying is this theory that it has been employed in many cases where anatomical changes were obvious. Thus Sir Andrew Clark, in his recent paper upon "Catheter Fever" before the Medical Society of London,[1] after describing a typical case of remittent fever following the introduction of the catheter in a patient of advanced years with prostatic hypertrophy, says: "The patient, supposed to be healthy, but suffering from an affection of the bladder, was a few weeks before my visit enjoined the daily use of the catheter, did well for about a week, then became ill and fell suddenly into the condition in which I saw him. He died within a week of our consultation. With great difficulty permission was obtained to make a post-mortem examination, and although it was made with both care and interest, nothing definite was found outside the bladder, and nothing in it to necessitate or account for death. The prostate was enlarged, the bladder was dilated

[1] Lancet, December 22, 1883.

and thickened—viewed from the inside it was trabecular and slightly sacular—the mucous lining congested and in part eroded, and everywhere coated with a grayish white, stinking mucus. There was nothing to be detected in the urethra or kidneys, although they were examined carefully." In seeking to explain the remittent fever which occurs so often, as in this case, at the commencement of habitual catheterism, Sir Andrew Clark says: "It probably begins in the nervous system; the disturbance of the nervous system reacts in the first instance upon the general metabolism of the body, and in the second instance upon the secretory organs, beginning with the kidney; that the effect upon the kidney may consist either in structural alterations of the kidney, or (as seems to be much more probable) in alteration of the constitution of the blood, that dynamic condition of its constituents in the renal vessels essential to the elaborative action of the secretory cells thereof; and lastly, that the concurrence of these conditions may and often is enforced by septic reabsorption into the blood."

The cases in question, similar to that described by Sir Andrew Clark, contained no necessity for a recourse to theories about reflex nervous action, even if such theories were made far more intelligible and coherent than that suggested; for these cases are readily explained upon mechanical principles already alluded to, namely, that the sudden removal of urine habitually present in a chronically distended and hypertrophied bladder occasions an intense congestion of the urinary tract which may involve the kidneys as well as the bladder, may even induce such engorgement of the kidneys as to produce complete anuria. The case which Dr. Clark selected as his text seems to have been a typical one of this category; not only the clinical symptoms, but also and especially the post-mortem appearances—the enlarged prostate, dilated, thickened, and trabecular bladder, the congestion and erosion of the mucous membrane—are those regularly found in cases of cystitis and pyelitis occurring in old men with prostatic hypertrophy and dilated bladder, as the result *not of the introduction of the catheter, but of the complete evacuation*—by the catheter, lithotomy or otherwise—*of an habitually distended and hypertrophied bladder.*

There is, so far as I am aware, no proof, either physiological or clinical, that a chronic and continuous reflex action, purely nervous, is ever manifested as the result of a solitary local irritation such as the introduction of the catheter. It may be asserted without fear of contradiction, that any chronic and continuous disorder of the urinary organs, traceable to the introduction of a catheter or sound or other operation in the urinary channel, is based upon morbid anatomical changes and is not of merely reflex nervous origin. The introduction of the instrument may be, it is true, the initial step in the pathological process; the catheter may empty an habitually distended bladder, the sound may accomplish the same result by dilating a tight stricture; but the disastrous consequences which follow in either case are due, not to the contact of the instrument with the susceptible mucous membrane, but to the mechanical congestion in the urinary organs, caused by the sudden removal of a chronic impediment and the relief of a chronic distention of the bladder, ureters, and kidneys. The morbid anatomical features of the case may be overlooked, or may be unappreciated, but they are nevertheless present.

Yet there are doubtless cases in which reflex action, purely nervous—that is without perceptible foundation in morbid anatomical conditions—can be properly assumed as the cause of urethral fever. These are acute cases, those in which the initial symptoms are manifested immediately, or at least within twenty-four hours after the introduction of the instrument;

which attain their acme in a few days at most; and terminate either in death (rarely) or in recovery within three days. In all of these there are symptoms indicating failure of the heart; in the most pronounced this failure may attain such degree as to occasion faintness, syncope, and even death, may be indeed termed "shock." In the less severe and usual cases, this failure of the circulation is indicated by coldness of the extremities and chill.

For these phenomena there is a physiological basis. That certain of the pelvic mucous membranes are intimately associated with important nerve-centres is demonstrated by both clinical and experimental observations. Mr. Savory emphasized this clinical fact, during the discussion upon Sir Andrew Clark's paper, in the following words: "Every surgeon must be familiar with the fact, which is confirmed by physiology, that during the administration of anæsthetics, after the power of reflex action has ceased in all other parts of the body, it can still be provoked by irritation about the urinary organs. If you decapitate a turtle and wait for some hours, the power of evoking reflex action dies out part by part, but the last part in which you can evoke it is the region of the cloaca." "I suppose it must be in the experience of every surgeon that occasionally, even in the very young and healthy, a considerable amount of shock is caused by the introduction of the instrument. I suppose it must have occurred to all of you to see in some cases, even after sounding children for stone, that a decided shock is produced by the operation." It is also in the experience of many surgeons that the introduction of an ordinary catheter or sound, even as far as the fossa navicularis, has been followed by chill and decided prostration of the patient; and it is comparatively seldom that a sound or catheter can be passed for the first time through the prostatic urethra even of a perfectly healthy man without causing at least some slight indication of nervous depression.

The urethra is not the only mucous membrane whose irritation may have a depressing effect upon the circulation; for it is a fact well recognized by surgeons, that during operations involving the anus and the rectal sphincters a patient under the influence of an anæsthetic is peculiarly prone to exhibit failure of the heart or respiration.

These clinical observations are supported by the results of an experimental inquiry which I made in the laboratory and with the co-operation of Professor Von Basch, in Vienna.[1] This inquiry was not undertaken for the purpose of supporting any preconceived hypothesis; indeed, the central fact demonstrated, that irritation of a mucous membrane may be followed by pronounced decrease of blood pressure, was discovered accidentally in pursuing another line of investigation. I was enabled to demonstrate that mechanical irritation of the mucous membrane of the vagina or of the rectum near their respective orifices, or of the anus or vulva, caused in curarized dogs an immediate and pronounced depression of the blood column and of the heart's action. This depression amounted in some instances to more than fifty per cent. of the entire blood column—an amount certainly ample to cause decided symptoms of nervous and circulatory depression if induced in the human animal. I was further enabled to ascertain that this effect was produced by a true reflex action involving certain branches of the sacral nerves, the spinal cord, and the splanchnic nerves; for the circulatory depression failed to appear

[1] Published in Du Bois Reymond's Archiv für Physiologie, 1882, page 298, entitled "*On Depressory Reflexes Generated by Irritation of Mucous Membranes.*"

after mechanical irritation, if the sacral nerves on the one hand, or the splanchnic nerves on the other were divided.

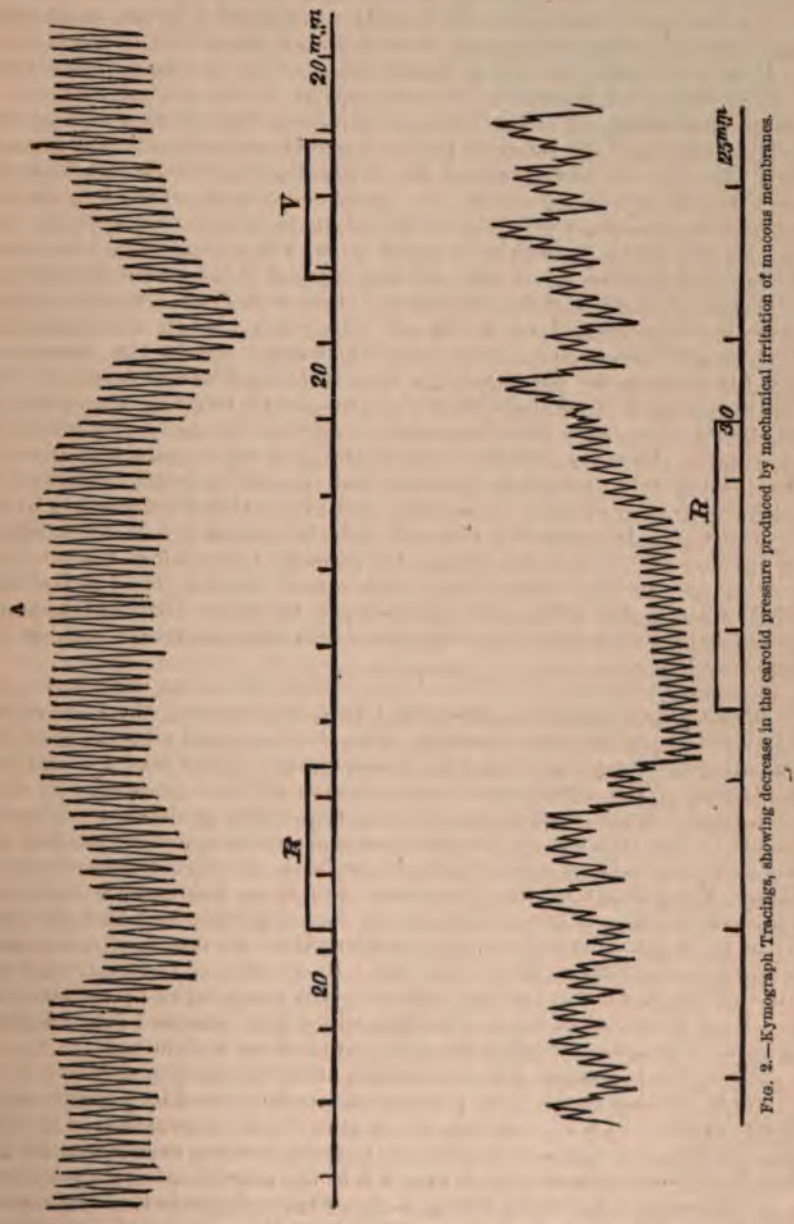

FIG. 2.—Kymograph Tracings, showing decrease in the carotid pressure produced by mechanical irritation of mucous membranes.

Two specimens of the kymograph tracings are appended (for others see the original article). In the engravings the abscissa is raised, to save space, 20 mm. in Fig. A, and 30 in Fig. B; the spaces between the ver-

tical lines on the abscissa indicate the intervals of time, each space representing 20 seconds in Fig. A and 30 seconds in Fig. B.

The time and duration of the irritation is indicated by the horizontal lines just above the abscissa; the locality is designated by the accompanying letters—*V* where the vagina was irritated, *R* in the case of the rectum.

It is thus experimentally demonstrated, as well as clinically observed, that a mechanical irritation, without injury, of the rectum and of the vagina, may cause, by reflex action; a decided depression of the general blood pressure. That the same power is possessed by the urethral mucous membrane, I have been enabled to satisfy myself, though not with the mathematical accuracy possible in experiments upon animals, in the following way: A fine glass tube is closed at one end with a close-fitting rubber cap, and is then filled with mercury to such a height that the weight of the metal is sufficient to shut off the current in the radial artery when the rubber cap rests upon the vessel. This is held in a wooden frame, which is also arranged as a rest for the wrist. When the forearm is placed in position in the frame, the tube is lowered until the rubber cap rests firmly upon the radial artery; so long as the blood is propelled with sufficient force to pass the obstructing weight of mercury, the surface of the metal in the tube exhibits the oscillations of the pulse; by gradually lowering the tube (by means of a rack and pinion) a point is reached at which the mercury ceases to oscillate, and the artery is fully compressed. A graduated scale attached to the rack and pinion shows the point to which the surface of the mercury sinks at different times before the artery is compressed. In this way a rough estimate of the relative force of the radial pulse under different conditions can be made. Thus it is found almost without exception that the pulse is stronger—that is, requires a greater weight of mercury to compress it—in the recumbent than in the erect posture.

In order to observe the effect of the introduction of an instrument into the urethra upon the blood pressure, I have, after placing the wrist of the individual in position and screwing down the column of mercury until the oscillations of the pulse were plainly transmitted, introduced a sound into the urethra. The result varies somewhat in different persons. In some cases, in which the urinary organs were apparently perfectly healthy, the contact of the instrument with the urethral mucous membrane has not produced any decided effect upon the column of mercury; in other instances the passage of the instrument has been followed at once by a complete cessation of the oscillations in the tube, indicating that the force of the pulse was diminished; the withdrawal of the instrument was soon followed by a return of the oscillations. In one case of tight stricture, the introduction of a conical sound until its point was grasped by the stricture occasioned an arrest of the oscillations, which were resumed only after the lapse of several minutes after the withdrawal of the instrument.

While this apparatus does not furnish such delicate and accurate registration of the changes in blood pressure as can be secured by a canula in the artery attached to a kymograph, yet it affords a demonstration of the fact that the introduction of an instrument into the urethra, even a normal one, may, in certain cases, cause a depression of the general arterial pressure.

Conclusions.—A general survey of the subject suggests that the various morbid conditions which may be excited by the passage of sounds and catheters into the urethra and bladder—comprising among others the somewhat ill-defined groups of symptoms known as "urethral fever"—are due to various causes, chief among which may be named the following:

1. *Reflex action*, a purely nervous phenomenon without appreciable anatomical lesion. This may be aroused even by the skilful introduction of a catheter or sound into the normal urethra and bladder; also by the introduction of an instrument for the dilatation of stricture, with or without lesion to the mucous membrane. The phenomena of the reflex action may vary in degree from a slight chill and general depression without fever, to anuria, syncope, and collapse; anuria is to be feared when the kidneys are already diseased. But whatever the degree of the symptoms they are always manifested, when due to reflex action, within a few (3 to 6) hours after the use of the instrument, and may even begin before it is withdrawn.

That this predisposition to exaggerated reflex effect of catheterism varies extremely in different persons is well understood; nor are there any rules for predicting the amount of disturbance which may be excited in any given individual whose urinary organs are in the normal state; the predisposition is certainly greater in cases of existing disease of the urethra, especially stricture; and it is usually asserted that the reaction—of purely nervous origin—is greater in persons of nervous and irritable temperament, in those of a gouty or rheumatic diathesis, in the subjects of chronic malarial infections, and (possibly) in those who have long lived in hot climates.

2. *Laceration of the Mucous Membrane of the Bladder or Urethra.*—So long as these are of slight degree they seem to have no special effect; doubtless in most cases in which a reaction follows a slight lesion to the mucous membrane, it is traceable not to the wound but to a nervous reflex action such as frequently occurs without laceration. At any rate, a slight injury to the mucous membrane is certainly not of itself sufficient to arouse urethral fever, and in the majority of cases has no such effect.

When, however, the lesion is more serious, either because more extensive or because its location predisposes to the accumulation and decomposition of urine, such laceration may become the starting-point for a pyæmic affection. In this case the symptoms are not developed in less than two or three days after the introduction of the instrument. The patient may of course exhibit both phenomena—a nervous chill due to reflex action and occurring within a few hours after catheterism, and an independent chill due to septic absorption, occurring one or more days later.

3. *Congestion of the Urinary Tract, caused by the Sudden Evacuation of a Habitually Distended (and usually Hypertrophied) Bladder.*—This cause is responsible for the so-called urethral fever—which is really the beginning of cystitis, pyelitis, and nephritis—which follows the use of the catheter in cases of prostatic hypertrophy; and is seen with especial frequency at the beginning of habitual catheterism or "the commencement of catheter life" in old men; the same condition results from the cutting or rapid dilatation of stricture in the posterior urethra, and is responsible for much of the illness and mortality following operations for stone in the bladder.

4. *An aggravation of pre-existing renal disease* by the sudden removal of a habitual impediment to the evacuation of the urine. This is, of course, of essentially the same nature as the congestion of the urinary tract previously mentioned. So far as I am able to ascertain, both from personal experience and from the observation of others, the use of the catheter never excites nor aggravates an inflammation of the kidney except in those cases in which an impediment to the evacuation of the urine has long existed. In this case there exists, as has been already emphasized several times in these pages, an excessive pressure in the ureters and pelves, which may even ex-

tend to the urinary tubules of the kidneys; and it is the sudden removal of this accustomed pressure by instrumental interference in the urethra or bladder which occasions an intense congestion and aggravation of a pre-existing inflammation; in fact, this congestion may of itself excite an inflammation in kidneys which had previously exhibited no signs of such condition. If the kidneys be extensively diseased, the introduction of a catheter may be followed by complete and fatal anuria, even though the bladder be normal. In this case the effect is produced not by the evacuation of retained urine and institution of an inflammatory reaction, but simply by the reflex disturbance of the renal circulation. Such reflex anuria may be produced even in normal kidneys, but is more probable if the organs be disorganized by disease.

3. *The Introduction of Septic Matter into the Bladder by the Use of Unclean Instruments.*—As has been already stated, such introduction occasions no appreciable reaction in cases in which the bladder is quite normal and evacuates itself completely. But in most instances in which the use of an instrument is necessary, the bladder is not in its normal condition and does not evacuate itself completely. Whenever there exists a habitual retention of "residual urine" in the bladder, the introduction of septic matters upon an instrument is followed by ammoniacal fermentation of urine and cystitis. If, as so frequently happens, the habitual distention with urine exists not only in the bladder but also in the ureters and pelves, this ammoniacal fermentation and consequent inflammation extends from the bladder to the kidney; such is the etiology of suppurative nephritis or "surgical kidney" as the result of catheterism.

Clinically it will be observed that the chill, fever, and other constitutional disturbance devoid of anatomical explanation, and therefore explained by reflex nervous influence, are exhibited within a very few hours after the passage of the instrument, perhaps even beginning during its introduction; while those conditions which are caused by circulatory disturbance, often culminating in inflammation, manifest the first symptoms rarely in less than twenty-four hours, and often after the lapse of several days subsequent to the passage of the instrument.

CHAPTER V.

PRECAUTIONS TO BE OBSERVED BEFORE CATHETERISM.

These consist chiefly in ascertaining, so far as may be, the presence of any disease of the bladder or kidneys previous to the introduction of the catheter. I wish to emphasize the word *bladder* in this connection, since many surgical teachers either ignore entirely the condition of the bladder or assign to it a very subordinate place, concentrating their attention upon the condition of the kidneys.

An individual who has no stricture, no prostatic hypertrophy, no tight phimosis or contraction of the meatus, no paresis nor atony of the bladder —in short, no inability to evacuate the bladder completely—can be (properly) catheterized without danger, no matter what the condition of the kidneys may be. The worst that can be apprehended in such a case is a pronounced nervous reaction. This may be so severe as to occasion the friends of the patient much alarm for a short time, and include fever, delirium, and even convulsions; but it is of temporary duration, and occasions no permanent disease. So far as I can ascertain by a careful examination of the literature, the only cases of death from "shock" after catheterism have been in individuals suffering from chronic disease of the bladder or urethra, or from acute over-distention of the bladder.

Various medicinal agents have been recommended and employed for the purpose of diminishing this liability to nervous reaction from catheterism; among these quinine and opium have been especially lauded, but, like the rest, have often failed. This failure is not surprising when we remember that the distinction between urethral fever of purely nervous origin on the one hand, and of anatomical source on the other, has not always been clearly recognized by surgeons.

The existence of stricture, prostatic hypertrophy, or other condition which may naturally induce habitual retention of more or less urine in the bladder, calls for the greatest care in catheterism. In such cases *the instrument used must be clean—surgically clean*—a condition attained by brief immersion in a weak solution of corrosive sublimate, and *the bladder must never be at once completely evacuated.* Considerable tact and judgment must be exercised in carrying out the last injunction, since we are not always in a position to know just how much urine is contained in the bladder. If this organ be distended with urine, as happens in those cases in which the catheter is required in consequence of the inability to void the urine, the quantity can be estimated by palpation and percussion over the symphysis; in such cases the catheter can be withdrawn when only half or two thirds of the urine is evacuated.

More frequent and more susceptible of injury are the cases in which there exists not an acute but a chronic retention of urine, in consequence of prostatic hypertrophy or stricture of small calibre. In cases of the

former class the catheter is introduced perhaps not to relieve an acute retention of urine, but as the commencement of the treatment necessary during "catheter life." In such cases it is all-important that at least half of the residual urine (if this exceed one or two ounces in quantity) be allowed to remain in the bladder. If the quantity of residual urine be great —six, eight, or ten ounces—its presence is readily detected by manual examination after the patient has evacuated the bladder so far as he can. It is not uncommon to find instances, chiefly elderly men with prostatic hypertrophy and thickened bladder, in whom rectal and abdominal examination reveals a tumor as large as the fist after the patient has, as he supposes, voided the last drop of urine. In these cases in which we can detect and outline the still partly filled bladder, we can estimate approximately the amount of residual urine before introducing the catheter, and then having permitted not more than half of this quantity to escape, withdraw the instrument. In many other cases we cannot determine satisfactorily how much, if any, residual urine remains after the voluntary act of micturition; in such cases the catheter is introduced and the size of the stream which issues from it noted; if this be full and strong, it is probable that several ounces of residual urine are present. In any case, however, in which the catheter reveals residual urine after the patient has exerted his entire ability in evacuating the bladder, not more than one or two ounces of this residual fluid should be permitted to escape at the first use of the instrument. Moreover, a saturated solution of boracic acid, equal in volume to one-half of the residual urine removed, should be injected and permitted to remain.

Similar precautions should be observed in introducing the catheter in cases of long-standing, contracted stricture; only a portion of the urine should be removed. In this way, and thus only, can we have an assurance of avoiding the most serious consequences, such as happened in a case which came under the writer's observation (and constitutes by no means an isolated or unique instance in surgical experience). In this case a man was admitted to hospital suffering from acute retention of urine caused by the effects of a debauch superadded to an old and contracted stricture. After various futile attempts with elastic catheters, a small conical silver instrument was introduced into the bladder, the effort occasioning trifling hemorrhage from the urethra. Nearly four pints of urine were evacuated. The catheter was used three times daily for two days, at the end of which time the patient had regained the ability to void urine. It had been decided to dilate the stricture, when, upon the third day after admission, the patient had a severe chill followed by fever, prostration, and the usual symptoms of the so-called typhoid condition. The urine became scanty and bloody. At the end of a week he died. The autopsy showed no recent lesion at the seat of stricture, but a hypertrophied bladder with well-marked trabeculæ and a diverticulum just at the right edge of the trigonum, dilated ureters and pelves. The bladder wall was soft, swollen, and contained numerous abscesses from the size of a pea downward; there was a perivesical inflammation and collection of pus between the bladder and rectum. The mucous membrane of the bladder was swollen, soft, injected, and at several places eroded. The kidneys were engorged with blood, and showed under the microscope numerous miliary hemorrhages. In short, the case was one of cystitis and pericystitis in a habitually distended and hypertrophied bladder. The cause of the inflammation was not nervous reflex action nor injury to the urethra, but the immediate evacuation of all the urine contained in the bladder, or the use of an unclean catheter, or both; a result which might have been avoided had the catheter been care-

fully cleansed before introduction, and *withdrawn when half of the contents of the bladder had escaped.*

The exploration with the sound or catheter affords certain information as to the condition of the urethra and bladder. A narrow stricture opposes the progress of the instrument; and if a conical sound of such size be used as permits the entrance of its point into the stricture, the instrument is observed to be firmly grasped by the urethra. This condition may be, however, simulated by spasmodic contraction of the urethral muscles in the membranous portion; the similarity is increased by the fact that the adjacent portions of the bulbous and membranous urethra are especially often the seat of stricture. To a practised hand the difference between the grasp of the compressor urethræ and of a stricture is usually apparent at once; if there be any doubt, it can be decided by maintaining a gentle pressure with the point of the instrument against the obstruction. A spasmodic muscular contraction soon yields and resistance vanishes; while a stricture, though dilating sufficiently to permit the passage of the instrument, still maintains an appreciable pressure and opposition.

The passage of the sound along the urethra may also reveal points of extreme sensitiveness; this condition is frequent after gonorrhœa, and may be due to the presence of eroded or granular areas, a question to be decided by the endoscope.

The passage of the point of the instrument along the prostatic urethra is usually, even in health, accompanied with an unpleasant, perhaps painful sensation. In cases of prostatitis, the patient experiences extreme pain which may amount even to agony, causing him to scream and struggle to escape the sound.

The introduction of the sound or catheter into the bladder should be made when this organ contains considerable urine; if it be empty, fluid should be injected, whence the advantage of using a catheter rather than a sound for exploring the bladder. By means of the instrument we ascertain the sensitiveness, the consistence, the smoothness, and the elasticity of its walls; the presence of foreign bodies or of tumors; and an approximate estimation of its normal capacity.

In its normal state the lining membrane of the bladder endures the gentle contact of the instrument without experiencing pain; it is uniformly smooth; it is sufficiently elastic to permit the point of the instrument to carry the wall of the bladder at least an inch beyond its original position, and to expel the catheter to the same extent when the pressure is removed. The short-beaked instrument already recommended can be rotated so that its point makes a complete revolution in the bladder without meeting any decided resistance.

In abnormal states the instrument often reveals decided departures from these characteristics. If the mucous membrane be inflamed, or if there be ulceration or a morbid growth present, the contact of the sound causes exquisite pain. In general cystitis the mucous membrane is everywhere thus sensitive; if there be ulceration from a malignant growth or other cause, this sensitiveness is usually localized.

Hypertrophy of the bladder wall is indicated by the presence of trabeculæ, hypertrophied muscular fibres separated by depressions. In this condition the point of the sound can be felt to scrape over the ridges thus produced. In cases of muscular hypertrophy, moreover, the bladder wall does not yield readily to pressure with the instrument. The presence of a foreign body or of a growth in the wall of the bladder opposes a localized resistance to the rotation of the sound. Morbid growths as well as calculi

are usually found at the base of the bladder; and it sometimes happens that the only tactile evidence of a neoplasm in the bladder is afforded by the resistance encountered in the effort to rotate the sound toward one side, while it moves readily toward the opposite side.

The careful injection of warm water through the catheter into the bladder may enable us to distinguish simple dilatation from dilatation with hypertrophy. In the former condition the bladder yields readily to the entering liquid, and expels it again in a feeble stream; if there be hypertrophy, on the other hand, the bladder tolerates but a small quantity of fluid, the distention of its wall arousing an irresistible desire for its contraction, by which the water is forcibly expelled.

In some cases the mucous membrane of the bladder is coated in spots with scales of phosphatic concretions; these give to the exploring instrument a sensation which may readily be mistaken for the roughness communicated by hypertrophied muscular fibres.

In many instances exploration with the sound is materially assisted by a finger in the rectum or by a hand over the symphysis. In the normal bladder the point of the instrument can be readily detected from the rectum, and (except in fleshy persons) above the symphysis. In abnormal conditions various bodies may be so interposed as to prevent such approximation of the finger and the point of the sound. Thus an enlargement of the middle lobe of the prostate may extend so far toward the fundus of the bladder that its upper edge cannot be reached by the finger in the rectum. Morbid growths, which are usually situated upon or in the immediate vicinity of the trigonum, may also prevent such contact, and can sometimes be defined between the sound and finger. Diverticula of the bladder—protrusions of its mucous membrane between the muscular fibres—are also usually found near the trigonum, and can sometimes be readily detected by conjoined examination. In one case of prostatic hypertrophy, with consecutive thickening of the muscular coat of the bladder, I was enabled to feel distinctly the entrance of the sound into the diverticulum with the hand which held the instrument, while with the finger in the rectum I distinguished its point projecting just to the outer side of the seminal vesicle.

By means of the sound in the bladder and a hand over the symphysis, it is sometimes possible to detect a thickening of the anterior wall such as may occur from a morbid growth located in this portion of the bladder. Occasionally a pedicled tumor attached to some other portion of the bladder wall has been detected in the same way.

A bimanual examination of the bladder has at times great advantages. This is accomplished by passing two fingers, or even the entire left hand as far as the thumb, into the rectum, while the right hand placed just above the symphysis exerts firm pressure downward and backward toward the rectum. The patient must of course be under the influence of an anæsthetic. In this way the body of the bladder is brought between the approximated ends of the fingers; and if the patient be not too fleshy, the organ can be explored with considerable delicacy. Volkmann states that he has been enabled in this way to detect the presence of a stone as small as a bean. He advises that, in children especially, the object in the bladder be pressed by the fingers in the rectum up against the abdominal wall, where it can be seized and outlined by depressing the skin around it. He has thus been enabled to estimate with accuracy the size and shape of a calculus. The method is, of course, not devoid of danger to both rectum and bladder.

CHAPTER VI.

DIGITAL EXAMINATION OF THE BLADDER.

By the methods already described the condition of the bladder can be ascertained with sufficient accuracy in most cases. They are especially satisfactory in the female ; for a finger in the vagina, with or without the assistance of the hand over the symphysis, affords more definite and satisfactory information than can possibly be obtained by rectal examination in the male. The entire cavity of the bladder is thus brought within the range of palpation ; the trigonum can be outlined, and its apices can be, with a little practice, distinctly recognized. This is an anatomical point of some importance, since by means of a vaginal examination the orifices of the ureters, located at the angles of the trigonum, can be located and retained in position while a catheter is introduced into them.

The introduction of a sound enables the surgeon to explore the vesical wall with this instrument, and to include a considerable portion of it between the finger in the vagina and the point of the instrument in the bladder. Calculi or other foreign bodies (the latter more frequently found in the female than in the male bladder) and morbid growths can thus be detected and outlined.

In many instances it is extremely desirable to make a digital examination of the interior of the bladder. In the female this can be readily accomplished by *dilatation of the urethra.* This procedure, which was first brought prominently before the profession by Simon, of Heidelberg, is readily executed ; but it has been found to contain possibilities of injury and danger which were hardly appreciated by the surgeons who first employed it, and it should be practised only when less radical methods of examination fail to furnish the information required.

Simon used, for this purpose of rapid dilatation of the urethra, a series of dilators made of hard rubber. These instruments were seven in number, constituting a gradually increasing series, the smallest about one-third of an inch, the largest nearly an inch and a quarter in diameter. They were introduced in succession, each being allowed to remain from one to two minutes. The largest has a circumference equal to that of the ordinary forefinger, which can therefore be introduced into the bladder immediately after the removal of the largest dilator.

These instruments of Simon have been superseded by dilating specula. It is extremely important that a proper instrument be used, since if the dilatation be effected, as is usually the case, by means of some instrument designed for another purpose—such as uterine dilators, polypi forceps, etc. —laceration of the mucous membrane and incontinence of urine are almost inevitable. It is important that the distending force of the instrument should be distributed equally around the entire circumference of the urethra and not upon two or three points only, as occurs when uterine dilators, etc.,

are employed for this purpose. The dilatation should be continuous, uniform, and gradual; the instrument should be so constructed as to permit the exercise of much or little force, according to the resistance to be overcome. The combined dilator and speculum, devised by Stein, of New York, is a most satisfactory instrument for securing these results. If this be properly employed, there is but little danger of serious laceration or more than temporary incontinence; with it the preliminary incisions of the urethral orifice, which Simon was in the habit of making, are unnecessary. Before using other instruments three incisions may be made, two lateral ones a tenth of an inch deep, and one at the inferior border of the meatus, a quarter of an inch deep. In using Stein's dilator, "the patient being on the back or side and anæsthetized, the instrument is introduced and rapidly dilated to a point at which some resistance is felt, when the dilatation is proceeded with more slowly and cautiously, the canal being stretched a few millimetres at a time, the force exerted being in inverse proportion to the resistance to be overcome, and a sufficient interval of time always allowed to elapse for the tissues to relax before further dilatation is made. In this manner the instrument is gradually expanded to the circumference of the index finger, or if need be to its fullest capacity, which is six and a half centimetres."

Dilatation with the fingers alone, so frequently performed, is productive of most disastrous consequences, and is always fraught with danger. I have seen perivesical inflammation and abscess, and even fatal peritonitis, caused by this digital dilatation.

The degree of dilatation permissible varies, of course, with the age of the patient as well as in different adults; the pain and danger of laceration are proportionate to the rigidity of the canal, which is usually most pronounced at the meatus. Simon directed that in patients under fifteen years of age the urethra should never be dilated more than 1.5 to 1.7 ctm. in diameter; and that in the adult female the calibre of the canal should not be made to exceed 2 ctm. This is a safe rule; yet in many instances the dilatation has been carried to a much greater degree without ill results; both index fingers, or a finger and forceps, have been simultaneously introduced into the urethra without causing even temporary incontinence.[1]

When the forefinger is introduced into the bladder, the middle finger of the same hand rests in the vagina, while the other hand, placed above the symphysis, presses the abdominal wall downward so as to bring the fundus of the bladder within reach of the exploring finger.

Unless every precaution be taken, including anæsthesia of the patient, the choice of a proper instrument, the utmost gentleness in manipulation after the introduction of the finger into the bladder as well as during the dilatation of the urethra, this operation is fraught with danger. In favorable cases there may occur nothing worse than incontinence of urine for a few hours; in other instances this incontinence has persisted for weeks or months; in still other cases—probably only when gross errors are committed—pelvic inflammation and abscess, and even peritonitis, have followed.

Digital exploration of the male bladder can be made through a perineal incision, a method of exploration recently employed and brought prominently before the profession by Sir Henry Thompson and Mr. Whitehead. The operation consists simply in external urethrotomy in the membra-

[1] Schatz, Winckel.

nous portion; the novelty lies therefore not in the operation itself, but in its performance for the purpose of permitting digital exploration of the bladder. A grooved staff is introduced, an incision made in the raphe of the perineum to the membranous urethra, which is then opened sufficiently to admit the index finger of the left hand; this is then pushed through the urethra to the bladder. If the anæsthesia is so complete that the abdominal muscles are quite relaxed, pressure with the right hand above the pubes brings nearly every portion of the surface of the bladder into contact with the end of the finger introduced through the urethra.

The operator carefully observes the condition of the vesical mucous surface, whether it is everywhere smooth, or roughened in spots; thickening of the mucous membrane, projecting villi, and neoplasms may be found; if bands of muscular fibres with intervening depressions are distinguished, the bladder is hypertrophied; in such cases a careful search for calculi should be made, since these may be partially enclosed, or even entirely encysted in the cavities between the folds. In one of Thompson's cases (a woman), there was "found springing from the centre of the trigone a firm prominence, externally consisting of some soft structure and almost polypoid in form; but on drawing it forward in the attempt to ligature its base, this outer layer was first scratched through, when a hard calculus, about the size of an acorn, was disclosed and enucleated, the prominence disappearing."

Otis,[1] after performing median lithotomy and searching the bladder for a foreign body in vain, was about to discontinue the exploration when his finger grazed a soft, pendulous body as large as a bean; this was extracted and found to be an encysted calculus covered with clotted blood.

Sometimes a scale consisting of phosphates, or of a pseudo-membrane incrusted with urinary salts, has been detected and removed by the finger-nail; "indeed, it is difficult to say at present what may not be found, as fresh experiences have brought to light conditions to some extent not heretofore recognized" (Thompson). Even if no tumor, calculus, nor morbid condition of the surface be detected, great benefit is often derived by the repose secured to the bladder through this operation; a large rubber catheter introduced through the wound and permitted to remain for six or eight days, relieves the bladder from the necessity for contraction and has sometimes entirely removed the morbid symptoms which led to the operation, by giving rise to a suspicion of a foreign body in the bladder.

Digital exploration is justifiable and frequently useful, not only in those cases where the existence of a vesical tumor can be safely affirmed upon the symptoms present, but also in many other instances where the cause of the morbid symptoms may be obscure and undetected. Yet before the surgeon undertakes this operation, he should exhaust all the less serious and radical means of exploration, including a determination of the urethral calibre by means of the urethrometer, and the inspection of the urethra through the endoscope. For these instruments may reveal in a urethral construction, polyp, or granular surface, the source of and means of relieving symptoms which are referred to the bladder—irritability, pain, hemorrhage; if the morbid influence of slight urethral abnormalities be forgotten or ignored, the surgeon may be betrayed into performing a useless and unjustifiable exploration of the bladder. Premising that these methods of exploration have been employed, and have failed to explain and relieve the morbid condition, we may accept Sir Henry Thompson's

[1] Loc. cit., p. 546.

conclusions, based upon an experience of thirty-eight cases, as indications for the performance of urethrotomy in the membranous portion. He says:

"On carefully analyzing these cases there appear to be four chief forms of vesical disease, in which the operation of opening the urethra for the purpose of withdrawing the urine altogether by an artificial route, and so suspending the functions both of the bladder and urethra for a time, may render good service. Besides these, there remains a fifth class of cases, namely, those in which the operation is undertaken solely with a view of exploring, when the presence of a tumor may be strongly suspected.

"1. The first class consists of those cases, not unfrequently met with, in which all the symptoms of chronic cystitis have existed for a long period and in a severe degree, and which persist in spite of long-continued and appropriate treatment; while at the same time it is understood that the absence of material cause for the cystitis, such as stone, stricture, vesical incompetence, etc., have been ascertained.

"2. The second class of cases includes those examples of prostatic hypertrophy and of atony of the bladder in which that organ must be emptied by the catheter many times in the twenty-four hours, and in which painful chronic cystitis is obviously aggravated if not maintained by the necessary process of relief. These are usually cases in which the disease has existed for years, and which have arrived to all appearance at the latest stage, unless complete relief can be afforded.

"3. The third class embraces those cases, less rare perhaps than they have been supposed to be, in which the existence of impacted calculus or of adhering calculous matter may be suspected or may be known to be present by sounding.

"4. In the fourth class I placed those cases in which painful and very frequent micturition or bleeding, separately or combined, may have long existed; without signs of cystitis, the urine being clear, free or nearly so from mucous or purulent deposit; furthermore the cause of these symptoms has baffled the most careful inquiry. On exploration being made no organic change is discovered, no light is obtained on the diagnosis of the case, but the functions of the bladder and urethra are suspended for a week or so, and the patient gets well more or less completely." (It is in these cases especially that the endoscope and the urethrometer—means of exploration which Thompson does not yet employ—should be used before the bladder is opened; careful inquiry is not baffled until the urethra has been measured and inspected, and the urine examined; and any abnormalities thus discovered have been removed without relief to the vesical symptoms.) "Of this remarkable history there are six examples in the series, of which three perfectly recovered, besides three others in which great improvement took place but not complete recovery. The result of operation undertaken in the circumstances described as a last if not almost hopeless resource, has been surprising and fraught with great interest. I am disposed to think that there are some persons in whom an attack of cystitis with extreme frequency of micturition having been set up, the want to relieve the bladder every half hour or hour, at first natural and necessary, still continues after the local disease has passed away in spite of their efforts to overcome it, as the result of what may be regarded as persistency of a morbid habit in certain constitutions. I cannot further elucidate the pathological condition in any one of them, having discovered nothing by the investigation to account for the symptoms."

When we remember that Thompson recognizes no abnormality in the urethra which is not revealed by passing a No. 12 sound, we are inclined

to the suspicion that the possibilities of diagnosis were not exhausted in these cases by the exploration of the bladder; and this suspicion is strengthened by the meagre details of his cases in which the operation failed to afford relief. In one of these (case 41), the patient was a man aged forty-five. "Many years painful symptoms and treatment for alleged stricture which does not exist" (?). "During last twelve months great frequency of micturition; now every half hour night and day. Instruments have been passed by himself and others up to the neck of the bladder and then failed to enter. Examination shows that the neck of the bladder is distinctly tense, rigid on the lower aspect, but the short-beaked sound passes over it readily in the bladder; nevertheless there is no stricture, for No. 15 (English) will enter" (?).

"April 14, 1884. Exploration. The finger on entering the bladder encountered rugæ and a roughened surface of mucous membrane, especially at upper part of bladder. The neck of the bladder was exceedingly tight, grasping the end of the finger like a ring; I divided this at the lower border so that the tension ceased. Free bleeding followed. A tube was tied in four or five days. He recovered slowly, and gradually regained power to retain his urine; the intervals being from two to three hours in the middle of May."

Since in other cases the symptoms described have disappeared entirely after division of a slight urethral constriction, the calibre of this channel should be carefully explored in such cases before the bladder is opened; the passage of a No. 15 sound is certainly not conclusive evidence that the urethra is free from abnormalities, and is therefore slight justification for the operation performed in this case, which apparently did not reveal nor remove the cause of the difficulty, and appears to have furnished but little relief. Furthermore, it may not be forgotten that organic disease of the kidney, as well as undue acidity of the urine, may be manifested solely by symptoms which are referred to the bladder and which suggest the existence of vesical calculus or neoplasm. Otis had the rare opportunity of examining post-mortem a typical case of this sort.[1] Frequent and painful urination, pain in the glan penis, vesical catarrh, and an occasional admixture of blood with the urine, had been observed for two years; these symptoms were aggravated by riding in a cart. Careful and repeated soundings had failed to detect anything abnormal in the bladder. A congenital contraction of the meatus had been divided and a large instrument passed through the urethra with but slight benefit. A digital exploration of the bladder through the perineum revealed no cause for the symptoms. Even at the autopsy no explanation of the difficulty was discovered in the bladder, but "the kidneys were filled with tuberculous deposits."

When therefore all the less direct means of diagnosis have been employed in vain; after kidneys, urine, urethra, rectum, and genitals have been examined and suggestive abnormalities corrected without relieving the vesical symptoms, the digital exploration of the bladder may be performed. It has occasionally revealed a morbid condition which, while susceptible to relief, must necessarily escape recognition by other means than digital contact. Thus in one of Thompson's cases (a female) who had for three years suffered severely from frequent and painful micturition, the cavity of the bladder was very small, apparently because the vesical walls were extensively bound together by adhesions; these were readily

[1] Loc. cit., p. 567.

overcome by the finger. After the operation micturition was painless, though still frequent.

This operation has been performed more than fifty times by Thompson, Whitehead, and Morris, in cases where the bladder was believed to contain tumors or calculi; in many of these instances the suspected objects were found and removed through the incision. Thompson recommends it as easy of performance, practically devoid of danger, and capable of affording valuable information; he regards renal disease and cancer as contra-indications for its performance. Probably renal disease constitutes, *per se*, no objection except when it is secondary to habitual distention of the bladder. In one case of cancer of the bladder in which I performed the operation—not so much for purposes of exploration, since the diagnosis was already established, but as a means for relieving the patient from the torture consequent upon his frequent and painful urination—marked relief and decided benefit were secured. The tumors hitherto removed by this method have been chiefly polyps and fibromata. There is undoubtedly a large field for this procedure also in the detection and removal of certain enlargements of the prostate, particularly those in which the middle lobe projects into the bladder so as to impede or even prevent the evacuation of urine. Such fragments of the prostate have been repeatedly removed accidentally during the performance of lithotomy, cystotomy, and lithotrity, with great benefit to the patient; by the performance of this simpler and safer operation the same good results might be achieved.

CHAPTER VII.

INSPECTION OF THE URETHRA—ENDOSCOPY.

The attempt to render the mucous membrane of the urethra and bladder accessible to the eye has been the subject of many endeavors within the last thirty years. That it was possible to bring limited portions of the vesical and urethral membrane within the range of vision was demonstrated twenty years ago, and as a result exalted expectations of consequent advances in urethral surgery were entertained. These anticipations were, however, but meagrely realized; the few individuals who expended upon the subject the time and study necessary for a proper use of the complicated endoscopes then employed, did not succeed in convincing the profession at large that the instrument possessed a tangible value for practical purposes. The endoscope has been and is generally regarded as an interesting toy, whose practical usefulness exists only in the distorted imagination of enthusiasts. This impression, which still prevails largely in the profession, is based not upon practical experience—for comparatively few practitioners have had an opportunity to learn its use—but is derived largely from surgical writers on these diseases, who possibly express a prejudice rather than the result of ample experience. Thus Sir Henry Thompson, in the last edition of his "Clinical Lectures," says (p. 8): "I may tell you at once, that if a man has a good and a tolerably practised hand, with a fair share of intelligence, I do not think he will gain a great deal by the endoscope; and if he has not, I think it will be of no use at all." "In ninety-nine cases out of a hundred you can arrive at the necessary information without it." And notwithstanding the repeated demonstrations to the contrary, he persists in saying: "I may mention that no one has yet been able by its means to identify the veru montanum."

These statements, which because emanating from so high an authority, are generally regarded as expressing the actual state of the case by those who have no experience with the endoscope, are based upon the use of the complicated instruments contrived by Desormeaux and Cruise. And so far as these instruments are concerned, the statements doubtless represent approximately the actual state of the case.

It is quite otherwise, however, with the simple endoscope which has been in the last few years brought prominently before the profession of Germany and Austria by Dr. Josef Grünfeld, of Vienna. By his demonstrations to the Royal Society of Physicians in Vienna, as well as to numerous pupils, Grünfeld has shown that the endoscope has *in a certain limited field* the greatest importance in the diagnosis and treatment of urethral diseases. As evidence of the appreciation bestowed upon it, may be adduced the fact that Billroth and Lücke have devoted to the subject one volume of their "Deutsche Chirurgie," which has appeared as "Die Endoskopie der Harnrohre und Blase" by Dr. Grünfeld.

It was my privilege some years ago to enjoy the private instruction of

Dr. Grünfeld for many months, as well as to observe the practice of Professor Auspitz, of Vienna. Through my observation then, as well as personal experience since, I am convinced of the value of the endoscope as one important means in the diagnosis and treatment of urethral diseases. While it is undoubtedly true that the instrument has a practical value for positive diagnosis in comparatively few cases only, yet in these few cases it is absolutely indispensable, affording information which can be acquired in no other way, and furnishing the only rational and successful plan of treatment. Moreover, it has an extensive application as a means of negative diagnosis, that is, of excluding possible pathological conditions, and thus arriving at a correct conclusion. Most of the standard text-books on this subject impart a mistaken impression ; they demonstrate satisfactorily that the endoscope has a very limited field of usefulness, *but ignore its value in that limited field.* Even if we admit the accuracy of Sir Henry Thompson's sweeping assertion, that "in ninety-nine cases out of a hundred you can arrive at the necessary information without it," it is certain that in the remaining case no definite information nor successful treatment is possible without it ; and it is highly probable that in several of the ninety-nine cases actual inspection of the urethra will show that the "necessary" information secured without the endoscope is not accurate. That Sir Henry's impressions upon the subject are at least somewhat inaccurate, is shown by his statement that no one has yet been able to identify the veru montanum ; for this can be and has been readily identified by numerous observers. In order to settle all doubt upon the matter, Grünfeld introduced a needle by means of the endoscope into the urethral orifice of the ejaculatory duct in a cadaver in the Rudolf Hospital, Vienna ; the urethra was then laid open by the prosector, Dr. Chiari, and the needle was found at the point indicated.

The information which can be derived exclusively by the endoscope is required in comparatively few cases ; the instrument, even in its simplest and most valuable form, does not fulfil the exaggerated expectations which were entertained in the earlier years of endoscopy ; but as an accessory to the armament of the surgeon who deals especially with diseases of the urinary organs, it is absolutely essential. This opinion is, as already stated, the outgrowth of personal observation and experience, and is at variance with that prevalent in the profession and endorsed by most of our standard authorities ; yet it is gratifying to read in the last edition of Bumstead and Taylor (page 108), "It will readily be seen that, for the purposes of diagnosis, the endoscope proves itself to be an invaluable instrument in many cases, as, for instance, in those of urethral polypi, or excoriations which might otherwise escape detection. It reveals also the presence and the exact seat of patches of granulations, spots of herpes, etc. And as applications can be made through the tube it enables us to reach these parts directly."

Endoscopy is now, so far as the instruments and their manipulation is concerned, one of the simplest and easiest modes of examination employed in the diagnosis and treatment of genito-urinary diseases. There are required endoscopes or urethral tubes, a head or hand reflector, and a source of illumination.

The endoscope itself is simply a tube by which the urethral walls are held asunder so as to permit the passage of light rays. The simplest form, and the one which is capable of the most general application, is constructed, except as to calibre, like the ordinary cylindrical vaginal speculum (see Fig. 3).

The length of this—the "simple endoscope" of Grünfeld—varies from 6 to 13 ctm., exclusive of the external funnel-like rim. For the examination of the anterior urethra only, Grünfeld commonly uses an instrument 10 ctm. long; for the posterior urethra a length of 12 or 13 ctm. is required. In special cases an instrument 6 to 8 ctm. is sufficiently long. It is of course desirable to use the shortest instruments which confer the required length, since the loss of light increases rapidly with the length of the tube.

The calibre of the instrument varies also from 16 to 24 Charrière; the larger sizes furnish, other things being equal, a more distinct view because of the greater amount of light permitted to enter and return through the instrument.

For ordinary purposes four endoscopes suffice, two 12 ctm. long each, corresponding to 18 and 22 Charrière respectively; two others 10 ctm. long, having the same respective diameters.

FIG. 3.—Grünfeld's Urethral Endoscope with Conductor.

For special purposes other forms are used. For the inspection of the mucous membrane of the bladder in the male, the tube is made from 13 to 15 ctm. long, and its vesical extremity, cut obliquely, is closed with glass so as to prevent the urine from entering the tube. Another instrument used for the same purpose is shaped like a male catheter with a short beak, a portion of whose convex curve is replaced by a plate of glass. These two instruments have but little value in practice, since the inspection of the vesical mucous membrane is opposed by certain obstacles which are practically insurmountable and which are not met in the attempt to view the urethra.

For practical purposes the simple straight endoscope is the most desirable and the most generally useful; in fact all the information of practical value which has as yet been obtained by means of the endoscope, is secured through this instrument; and it is naturally the only one which is useful in a therapeutical way, since it alone permits local applications. In the following remarks, this form alone is designated, unless it is otherwise specified.

USE OF THE ENDOSCOPE.

Having selected the instrument, shorter or longer and smaller or larger in calibre according to the requirements of the case, the employment of it includes attention to three points especially: 1. The position of the patient. 2. The arrangement of illumination. 3. The manipulation of the tube itself.

For the examination of the anterior urethra, the patient may simply sit upon a chair; in order to reach the posterior urethra, the patient must assume such a position as will permit an obliteration of the natural curves of the urethra. He should, therefore, lie upon a high table such as is used for operating purposes, the perineum being brought to the edge of the table while the feet, widely separated, are supported by chairs. Any one of the gynæcological chairs ordinarily employed in this country answers the purpose admirably, since the position required is practically identical with that assumed for the ordinary vaginal examination.

The illumination of the interior of the urethra is secured by means of light reflected from a head-mirror, such as is used ordinarily for examination of the larynx. The best light is by all means direct sunlight; and this should always be employed if it can by any means be secured. By means of it differences in color and configuration of the surface, the presence of dilated blood-vessels, etc., are far more readily distinguished than by any other mode of illumination. In the majority of cases, however, the use of direct sunlight is impracticable, and the operator is compelled to fall back upon artificial sources of illumination. The relative value of these is determined by their brilliancy; hence an electric or magnesium light is best, though of course, rarely procurable. Except in rare cases a perfectly satisfactory illumination is secured by the reflection of light from a gas or kerosene flame furnished with an argand burner. When such illumination is employed, other sources of light should be, as in ophthalmoscopic examinations, excluded from the darkened room.

The introduction of the instrument varies somewhat according as a metallic or a hard rubber endoscope is employed; the edges of the metal instrument are thin and sharp and would necessarily lacerate the mucous membrane; hence it is provided with a wooden plug which projects somewhat beyond the edge and terminates in a rounded extremity. The hard rubber instrument has thick and rounded edges which require no protecting plug for its introduction.

The operator stands between the knees of the patient, grasps the penis between the thumb and forefinger of the left hand and compresses it from above downward so as to convert the natural vertical slit of the meatus into a circular opening. The oiled endoscope is held between the first and second fingers of the right hand, the thumb being placed over the end of the plug so as to prevent its withdrawal into the metallic tube during the introduction. The end of the tube advances readily in most cases to the posterior extremity of the fossa navicularis, where it often meets some obstruction; this can be easily overcome by slightly rotating the instrument while at the same time a progressive movement is given it by the thumb upon the plug. No further impediment to the progress of the instrument is felt (in the normal urethra) until it reaches the anterior layer of the triangular ligament. An inexperienced hand frequently encounters some difficulty, merely because the axis of the endoscope is allowed to form a considerable angle with the axis of the urethra and thus impinges upon one or the other, usually the inferior wall. Careful attention to this point and correction of the position of the endoscope will obviate this difficulty.

If it is desired to inspect the urethra posterior to the bulb, it is necessary to depress the pendulous portion, so as to obliterate the angle at the bulb and permit the insertion of the instrument into the membranous portion through the opening in the triangular ligament. This requires considerable care, and may at first be the cause of much difficulty, since the

point of the instrument is often arrested in the sinus of the bulb. After the point has been successfully introduced into the membranous urethra, the distal extremity must be still further depressed in order to permit the endoscope to traverse the membranous and prostatic urethra. The passage of the instrument through this portion of the urethral canal is usually accompanied with some pain to the patient. In some cases it becomes necessary even with the longer instruments, to compress the penis in the direction of its length and thus enable the inner extremity of the tube to reach a portion of the canal which normally lies at a distance from the meatus greater than the length of the tube. Thus, with an endoscope 10 ctm. long, it is usually easy to inspect the bulbous and even the membranous urethra through this manœuvre, though the natural length of the canal may considerably exceed that of the tube.

When the point of the instrument has reached that part of the urethra which it is desired to inspect, or at least the deepest portion accessible with the tube in use, the fingers of the left hand, which have hitherto supported the penis, are now made to grasp also the funnel-shaped extremity of the endoscope and thus maintain it in position against the natural contractile efforts of the urethra to expel it. The plug or conductor is now withdrawn by the right hand and the mirror, attached to the head-band, directed so as to reflect light into the tube.

In nearly all cases the surface revealed is found covered by moisture, which must be removed in order to afford the best possible view of the mucous membrane. For this purpose a small tampon, made of cotton enclosed in a proper holder, or simply wound around a long slender piece of wood (uncut match stick) is introduced through the tube and pressed gently against the membrane. Upon withdrawing the tampon the field is again inspected, and if necessary again cleansed in the same way.

The entire urethra anterior to the point at which the end of the tube now rests can be inspected by gradually withdrawing the instrument toward the meatus. If at any time the operator desires to inspect again a portion of the mucous membrane posterior to the point at which the end of the tube rests, he should not forget to introduce the conductor before making any movement of the instrument toward the bladder ; for the sharp metallic edges of the tube, unless thus masked by the enclosed plug, may lacerate the mucous membrane, or at any rate cause the patient pain.

If the instrument used be made of hard rubber, no conductor is necessary, and the endoscope can be moved either forward or backward along the urethra without injury to the mucous membrane. In consequence of the thickness of material required and the consequent loss of calibre in this instrument, the metallic endoscope is for nearly all cases preferable, notwithstanding the peculiar inconvenience caused by the unavoidable employment of the conductor.

Diagnosis with the Endoscope.

A recognition of abnormal states of the urethra is of course possible only after the investigator has become thoroughly familiar with the appearances presented by the normal urethra in the different portions of its length. It would exceed our limits to enter into a detailed account of the features which characterize the normal and the numerous abnormal conditions of the mucous membrane, as observed through the endoscope. It must suffice to point out a few of the most important of these as instances of the scope of the instrument.

The endoscope finds its most frequent application in the diagnosis and treatment of *chronic inflammation of the mucous membrane*, occurring as a continuation of gonorrhœa, and usually, though not always, accompanied with gleet. In such cases the location of the diseased portions can generally be readily defined by means of the endoscope, and topical applications made with certainty and accuracy. Such diseased surfaces may occupy an extensive area, or may be localized in small patches of the urethra.

If the existence of such a surface be suspected and its examination with the endoscope undertaken, it may be advisable to locate it so far as possible by the use of the ordinary bulbous or acorn bougies. The passage of the bulb of this instrument over the chronically inflamed surface usually occasions a more or less painful sensation. It is, however, a singular fact, noted by almost all who have employed the endoscope, that the location of the diseased patch by the sound rarely corresponds with the actual seat of the pathological condition as revealed to the eye; the discrepancy is caused by the variation in length which the urethra so readily undergoes during manipulation.

The existence of a localized chronic urethritis is revealed through the endoscope in the following appearances: the middle of the field is usually occupied by a drop or two of pus, the removal of which shows a short, funnel-shaped depression. The reflection of the light, which in the normal condition causes a bright ring a short distance internal to the tube, now consists of several irregular and often interrupted curves, quite different both in shape and location from the normal circle.

A close inspection of the surface reveals the existence of numerous slight elevations, such as are often observed on the surface of the conjunctiva in cases of granular lids. Such a surface bleeds readily, an escape of blood being perhaps excited by the simple contact of the instrument; while in other cases the lightest touch of the tampon, necessary for the removal of the pus which may be present, causes an oozing from the granular surface. The withdrawal of the tube a short distance so as to bring into view a portion of the normal urethra, exhibits clearly the difference between the characteristics already mentioned and those of a healthy mucous membrane.

A thickening of the epithelium of the urethra is an occasional, possibly a frequent, condition, which is in some cases at least responsible for a chronic urethritis or gleet. It is the result either of a gonorrhœa or of the frequent and habitual use of instruments, having been noticed in those who have been in the habit of introducing bougies or catheters at intervals during a long period. In some cases this thickening of the epithelium, with or without an increase in the submucous connective tissue, occasions such a narrowing of the canal as to be perceptible by the sound or bougie; yet in other cases this epithelial thickening does not encroach upon the calibre of the urethra sufficiently to be detected by the ordinary means of exploration. This has been repeatedly observed upon post-mortem examination, and has been remarked by Dittel; I have myself seen two instances.

The frequency of this condition cannot be stated, since without the use of the endoscope it can be determined only post-mortem, and is not usually sought for during autopsies. They do exist, however, and can be easily recognized during life when the mucous membrane of the urethra is rendered accessible to the eye by means of the endoscope. They are then seen either as bluish white stripes, or as patches of greater or less area which present the same bluish white color. These usually exhibit a

decided elevation above the general surface ; sometimes by following them the observer arrives at a point where the projection into the lumen of the urethra constitutes a decided stricture, while at other times the projection above the general urethral surface is insignificant.

This epithelial thickening originates, in some instances at least, in an acute inflammation or in the constant irritation produced by the passage of instruments. In other cases it cannot be traced to either of these causes, its etiology being as obscure as that of certain thickenings of the epithelium of the tongue occasionally observed. The former cases are generally accompanied by a slight urethral discharge, often observed chiefly in the morning, and occasionally furnishing threads —" tripperfäden "—in the urine.

Grünfeld has observed several cases in which this condition of the urethra was plainly perceptible ; one of these he demonstrated to the Royal Society of Physicians in Vienna in May, 1879.

The termination of these cases is various ; in some the epithelial thickening, and with it the symptoms complained of, were readily removed by simple topical applications such as iodine in glycerine, while in other instances the treatment adopted seemed quite ineffectual.

Tumors of the Urethra.—In the recognition and treatment of urethral tumors the absolute necessity of the endoscope is most plainly marked ; in fact, the surgeon who undertakes the treatment of genito-urinary diseases without employing this instrument is liable at any time to meet a case whose etiology and treatment baffle him entirely, however skilful and familiar he may be with other modes of exploration and treatment. These cases of urethral tumor are probably rare in the male ; such at least is the assertion of nearly all surgical authorities. The rarity of the cases which have been clinically recognized as such is doubtless explained in part by the fact that the endoscope, which affords the only means for detecting and recognizing them, has been but little employed. The urethral tumors discovered by other means than endoscopy have been seen almost exclusively post-mortem ; in a few cases the introduction of a catheter has been, much to the surprise of the surgeon, the means of removing a urethral polyp which had become entangled in the eye of the instrument. Comparatively few urethral tumors have been discovered even upon autopsy, a fact which does not necessarily prove the extreme rarity of these growths, since in many parts of the world the urethra is not examined post-mortem except in those cases in which a suspicion of urethral difficulty has existed before death ; the systematic examination of the urethra during autopsy would doubtless reveal such growths somewhat more frequently. At any rate, during a series of seventy autopsies in which I laid open and examined the urethra, I found two cases in which a well-marked polyp existed ; in one the growth was a slender pedicled tumor five-eighths of an inch long, attached in the floor of the prostatic sinus, just to the right of the middle of the veru montanum ; in the other a somewhat globular outgrowth of the mucous membrane, as large as a small pea, was found about the middle of the fossa navicularis.

It would seem indeed that however rare other tumors of the urethra ought to be, polyps—simple hypertrophies of the mucous membrane—might reasonably be expected with some frequency in cases of previous gonorrhœa or gleet. The enlargements of the papillæ known as pointed condylomata are, as is well known, the frequent and rapid products of the irritation caused by a gonorrhœal discharge, the secretion from a venereal sore, or even the accumulation of smegma under the prepuce ; that a simi-

lar hypertrophy should occur as the result of an irritation of the mucous membrane of the urethra would seem plausible. That such growths do occur more frequently than the general literature of the subject would lead one to infer is indicated by the fact that twenty-three cases have fallen under the notice of one observer in a very few years.

The *symptoms* caused by the presence of a polyp in the urethra vary extremely, according to the location and size of the growth. In many cases such a tumor seems to have occasioned no particular symptoms, or at least none which have aroused the suspicion of the existence of a neoplasm in the urethra. In other instances the symptoms have been such as are considered indicative of a disturbance (often functional) of the prostate, bladder neck, or genital organs proper. Thus in one case reported by Genandet, a student twenty-two years old who had never had gonorrhœa nor syphilis, began to complain of seminal losses, at first as nocturnal pollutions only; later a loss of semen occurred during the day at stool, as was demonstrated with the microscope. Then followed various symptoms—emaciation, failure of vision, mental sluggishness, frequent urination, dull pain and a sense of weight in the perineum and in the spermatic cord. Cauterization of the ejaculatory ducts, as recommended by Lallemand, was performed. Upon closing the instrument in the urethra a resistance was felt, and upon withdrawal a polyp was found entangled in it. All the symptoms complained of disappeared, and had not returned sixteen months later, at which time the report was made.

A case which, through the kindness of Dr. Grünfeld, I had the opportunity of observing, was equally striking; for the symptoms exhibited are such as are referred by the standard authorities to stricture, or prostatic inflammation, or both. A gentleman thirty-five years of age, himself a physician, had seven years previously suffered from an obstinate gonorrhœa. For several years thereafter he experienced no difficulty, subjective or objective, in the genital or urinary functions. Some five years after the attack referred to, he noticed a slight dribbling of the urine after the apparent completion of the act. This dribbling, at first of occasional occurrence and insignificant amount, gradually became a serious annoyance. He was compelled to urinate frequently; after each act, often even after the clothing had been arranged, a quantity of urine sufficient to saturate the underwear was involuntarily expelled, thus compelling him to change his linen at very short intervals, to escape the urinous odor. On several occasions there was some hemorrhage from the urethra; twice this was quite profuse, once during intercourse, and once during a simple erection without further provocation. Urination became frequent and slightly painful.

The patient at first assumed the existence of a stricture as the cause of the difficulty, but careful examination failed to reveal any contraction in the urethral calibre. Nevertheless steel sounds were introduced almost daily for a considerable period, in the hope of effecting relief. After the failure of this measure, the doctor presented himself to Grünfeld for endoscopic examination. In withdrawing the instrument, Grünfeld discovered on the floor of the urethra, at about the middle of the pendulous portion, four distinct polyps, the largest about the size of an ordinary pea, and all situated within a space of one inch. These were at once removed by means of the snare, an operation causing some little pain but inconsiderable bleeding. The result was entire relief from the symptoms complained of. During the six months following I met the patient on several occasions, and was informed that both genital and urinary functions were normally

performed, and that he had enjoyed, since the operation, entire freedom from the previous annoying symptoms.

Various symptoms, subjective and objective, usually produced by other conditions, have been observed in special cases to be dependent upon the presence of polyps in the urethra. Among these are frequent and dribbling urination, hæmaturia, a gleety discharge, the sensation of a foreign body in the urethra, cystitis; indeed, many of the symptoms of stricture, including impediments to the introduction of the sound, have been traced to the same cause. In women, in whom the diagnosis is easily made, urethral polyps are known to cause various symptoms of womb disease, pruritus, painful urination, etc. In one case reported, cystotomy was performed in an elderly man to relieve an obstinate cystitis. The patient wore a canula until his death, seventeen months later; at the autopsy, it was found that the cause of the trouble was a small polyp situated at the vesical orifice, whereby the urethra was completely closed.

Dr. H. G. Klotz, of New York, reports[1] an interesting case, showing the dependence of gleet upon urethral polyps. The gleet had continued since an attack of gonorrhœa, three years previously. Examination detected a stricture 13 ctm. from the meatus, admitting No. 14 French; the passage of steel sounds caused slight hemorrhage. In a few weeks the constriction was dilated to No. 27 French, but small olive-pointed bougies were always arrested near the seat of the stricture; the discharge continued almost as profuse as before. Examination with the endoscope revealed several polyps in the membranous urethra; about a dozen of them, varying in size from a canary seed to a pea, were removed in several sittings. "Under the application of caustics and astringents, the mucous membrane is returning slowly to its normal condition, the seat of the former stricture being recognized by the scar-like, perfectly white appearance of the mucous membrane of the upper wall of the urethra, immediately in front of the seat of the polypi."

The diagnosis of urethral polypus can be made with the endoscope only, and the treatment likewise consists of removal or of cauterization through the tube. In cases in which persistent symptoms referable to the genito-urinary tract cannot be explained by anatomical conditions revealed by the usual modes of exploration, the possibility of urethral polyp should be borne in mind and an endoscope examination made. Such examination requires the most careful and thorough inspection of the entire urethral surface, first in front of the bulb and subsequently, if this examination prove negative, in the posterior urethra. In this examination it is essential to inspect not only the central field as seen when the endoscope is held parallel with the axis of the urethra, but also the walls of the canal. To do this, the endoscope should be diverted to one side and the other, above and below, by making the tube form a slight angle with the urethra.

Sometimes a distinct tumor can be recognized in the field of the instrument; in many cases attention is first attracted by the sudden displacement of the ordinary field by what seems at first to be merely a fold of mucous membrane, which displaces partially or completely the central cone or funnel made by the normal urethra. The new growth pops suddenly into the field, as it were. A somewhat similar appearance is sometimes seen if the endoscopic tube is suddenly turned from the axis of the urethra toward its wall. In order to be certain that the object seen is really a new growth, it is necessary to secure a field in which the usual

[1] Medical Record, July 30, 1881.

cone or funnel is partially obscured by the projecting mass. It is also to be remembered that the normal appearance in the prostatic urethra is somewhat similar to that produced by a small sessile polyp in the pendulous portion, for the veru montanum projects upward from the floor of the urethra so as to partially obscure the field. It is said that an enthusiastic endoscopist once undertook to remove a portion of the veru montanum, in the fond belief that he had discovered a urethral polyp.

Pedicled polyps do not usually indicate their presence by thus suddenly appearing in the field during the withdrawal of the endoscope. They are generally visible as bright red protuberances, occupying a larger or smaller part of the field, the remainder of which is composed of a crescentic portion of mucous membrane, usually of lighter color than the polyp itself. This crescent varies in size according to the dimensions of the tumor; if the latter be small it may be surrounded entirely by a ring of mucous membrane visible in the field. If the tumor be small and the pedicle comparatively long, the bright red object can be pushed backward by the movement of the endoscope; if, on the other hand, it be large, the polyp occupies more of the field as the instrument is withdrawn and may finally completely fill the end of the endoscope, causing, of course, the disappearance of the cone ordinarily seen. Grünfeld lays especial stress upon the shadow cast by the tumor when this occupies but a portion of the field; the shadow increases and diminishes according to the position of the instrument and the amount of the polyp included in the field.

Polyps of the urethra vary considerably in size and in the number found in the same individual. The largest yet reported as observed during life was one detected and removed by Grünfield; this was 25 mm. long and 13 mm. broad. In another case demonstrated to the Vienna Medical Society, five polyps, one as large as a pea, were observed.

Simple granulations occurring as the result of gonorrhœa also occasionally constitute tumors recognizable with the endoscope. These are usually surrounded by a granular area, as already described; yet the latter may exist without any distinct granulations of such size as to project into the lumen of the urethra. Such fungous granulations are readily detected with the endoscope as bright red masses, usually covered with a layer of pus and bleeding readily upon pressure even with the tampon of cotton. They are frequently present in cases of gleet, and render the affection extremely obstinate, as in the following personal case: A man twenty-six years of age consulted me regarding a gleet, which had existed for the previous nine months. He stated that five years previously he had had a gonorrhœa, and two years subsequently had been informed by a physician whom he consulted concerning various urinary irregularities, that there was a stricture in the anterior portion of the urethra. The stricture had been dilated up to No. 12 English, and the patient instructed to pass a sound every week—an injunction which he had of course neglected to carry out more than a short time. About a year previous to his visit to me, and therefore two years after the dilatation of his stricture, he had acquired a second gonorrhœa; the discharge had never ceased entirely.

On examination I found a stricture admitting No. 17 Charrière, about one and one fourth inch posterior to the meatus; there was a slight but constant semipurulent discharge. I dilated the stricture gradually until it admitted readily No. 28, expecting that the discharge would probably cease. In this I was disappointed; for two weeks after the dilatation of the stricture up to the point named there was still a discharge. An examination with the endoscope showed that for three-fourths of an inch

back of the stricture, the mucous membrane was unusually red and vascular. Several minute granular points were observed, and on the right wall was a mass of flabby granulations covering an area about an eighth of an inch in diameter. The removal of this mass with the snare and the application of bluestone to the base and surrounding surface was soon followed by a complete cessation of the discharge.

The conditions already mentioned constitute the greater number of cases in which the endoscope is essential for purposes of diagnosis. There are, however, various other abnormal conditions of rare occurrence, which can be recognized and successfully treated only with the aid of this instrument. The veins contained in the urethral walls are sometimes enlarged and varicose, a condition which may give rise to various uneasy sensations referred to the glans, the urethra, or the bladder-neck; these varices are readily recognizable with the endoscope.

Erosions and Ulcers of the Urethra.—These probably occur as the result of gonorrhœa, causing an obstinate and persistent discharge which defies all other modes of treatment than topical applications. Such cases have never fallen under my own notice, but have been described by various writers on endoscopy. Thus Grünfeld exhibited in the Vienna Royal Society of Physicians in 1877 "a man who had suffered for several years with chronic urethritis, on the under surface of whose urethra two ulcers, visible through the endoscope, were seen. One of these was located between five and six centimetres, the other from one to two centimetres from the meatus. The former was 1 ctm. long, of nearly triangular form. The anterior of the two was of horseshoe shape, the arms being 10 and 12 mm. long respectively. These ulcers were quite superficial and were easily healed by pencilling with a solution of lunar caustic and with sugar of lead."

The same observer reports having repeatedly seen gonorrhœa, or rather urethritis, which was certainly not due to intercourse, in individuals who were subject to herpetic eruptions on the glans and prepuce. Examination with the endoscope has shown herpetic blisters within the urethra. He asserts that the cure of these blisters by local applications has been followed at once by the cessation of the discharge.

Certain abnormalities of the mucous membrane possessing clinical importance are most readily or exclusively detected by the endoscope; such are diverticula, local dilatations and valvular folds of the urethra. Such abnormalities are rare and have but little importance except after the occurrence of urethritis; under these circumstances any of the conditions mentioned may be responsible for the inexplicable obstinacy of a chronic discharge. A case of sac-like dilatation of the urethra is related by Grünfeld:[1] "The subject was a medical student who in the summer of 1874 experienced for about four weeks after every micturition a sensation as if a portion of the urine had remained in the urethra; yet pressure never succeeded in evacuating such additional quantity. The urine was clear. In the summer of 1876 the patient noticed a dribbling of the urine after micturition. The duration of this dribbling as well as the quantity gradually increased, so that in 1877 it persisted for two hours after every act and the linen was correspondingly saturated. In the winter of 1877 there appeared after every urination an oval tumor in the vicinity of the bulb, by pressure upon which urine was evacuated. During the period immediately preceding this condition it had been noticed that the

[1] Loc. cit., p. 197.

semen expelled during frequent pollutions was almost completely evacuated, pressure upon the urethra expelling a drop or two. The systematic introduction of bougies (up to No. 12 English) was unsuccessful in changing the condition, except that the duration of the dribbling at each act was somewhat shortened (1878). The sac of the urethra was seldom completely evacuated. Entrance into a cold bath when the sac was full caused a complete evacuation of the same; but systematic cold bathing was unsuccessful in relieving the condition. The use of the Faradic current (fourteen sittings) occasioned immediate contraction of the sac, but no permanent benefit (December, 1878). As the patient suspected the existence of a valve in front of the sac, he presented himself to me for endoscopic examination (January 15, 1879). I found the diameter of the urethra in front of the bulb of extraordinary size, the transverse central figure having three times the usual length. The mucosa was otherwise normal and the urine quite clear. Endoscope No. 24 was used. I proposed thorough pencilling of the sac with tincture of iodine, in order to accomplish contraction in this way. The result was favorable, inasmuch as after the fourth pencilling the urine was completely evacuated three times. The urethra remained completely contracted for two days after each use of the pencil. The duration of this complete contraction of the sac after a single sitting gradually increased, so that, for example, in the time between February 24th and March 2d, no dribbling occurred, and on the latter date only a few drops remained behind. The pencillings were performed now less frequently, four times in March, three times in April, and once each in May and June. Since that time (two years) the patient has remained well."

The endoscope has been occasionally employed in cases of tight stricture as a means for discovering the entrance to the stricture and of assisting the introduction of a bougie; it has also been asserted to possess a value in cases of proposed internal urethrotomy. It is said that by inspecting the stricture it can best be determined at what portion of the urethra the incision should be made. The cases in which such application of the endoscope has a practical value must be infrequent.

The endoscopic examination of the bladder has been thus far a matter of purely scientific interest. Foreign bodies, calculi, the swollen mucous membrane, portions of tumors, and even the scars of operations have all been distinctly seen with the aid of this instrument; yet no information which cannot be acquired by other and less objectionable means has as yet been furnished by the endoscope so far as the bladder is concerned.

The difficulties which beset the endoscopic examination of the bladder comprise not only those encountered in the introduction of the instrument, but also the fact that the field of vision is even in the healthy bladder obscured by the urine; in abnormal conditions accompanied by an exfoliation of the epithelium, and perhaps suppuration in the bladder, this obscurity is such as to practically prevent endoscopic examination.

Grünfeld was the first to accomplish, by means of the endoscope, a manipulation which might in exceptional cases have extreme practical value—the introduction of a catheter into the ureter. This is of course possible only in females. It had been undertaken by Simon, who reached and recognized the vesical orifice of the ureter, not by the endoscope, but by the finger introduced through the dilated urethra. Simon performed this catheterization of the ureter seventeen times in the living subject, and in all but two cases was enabled to introduce the instrument as far as the pelvis of the kidney. In attempting to perform the same manœuvre with the endo-

scope, he always failed, notwithstanding the fact that the instrument employed was introduced through the dilated urethra and had a diameter of about two centimetres. Other observers, notably Winckel and Rutenberg, also failed to discover the orifice of the ureter. Grünfeld was, however, enabled to reach and introduce an instrument into the ureter of the female without previous dilatation of the urethra—an operation which he repeatedly demonstrated upon the cadaver. The value of the endoscope for this purpose has been, however, materially vitiated by Pawlik's demonstration that the same manipulation can be readily accomplished without endoscopic or other instrumental assistance.

Therapeutics with the Endoscope.—The value of the instrument is to be found almost as much in the treatment as in the diagnosis of urethral diseases. That the local application of remedies should be more successful when directed by the eye than when made haphazard by injections into the urethra is self-evident, and has been amply demonstrated in practice.

Local therapeutics with the endoscope require a few especial instruments adapted to the anatomical relations of the parts involved. These are :

Tampon;	Snare;
Pencil;	Scissors;
Caustic-holder;	Forceps.
Powder-blower;	

Some of these have a very limited use and are rarely required even in extensive employment of the endoscope. The tampon, pencil, and caustic-holder are indispensable, and the powder-blower frequently convenient.

The principles involved in the use of these instruments require no discussion, since the conditions which they are employed to relieve are identical in the urethra and in other mucous membranes, especially the conjunctiva. The general fact is to be remembered that applications to the urethra, especially the posterior portion, should be made with greater caution and conservatism than are required in the treatment of conjunctival affections ; since the reaction both local and general is apt to be greater, and in consequence of the anatomical relations, less readily controlled.

The *tampon*, consisting of a wad of cotton, can be held either in a clamp provided for the purpose, or wound around the end of a fine sound, as is customary in intrauterine applications. The disadvantage of either of these methods arises from the necessity of frequent change of the cotton ; for the tampon is in constant use in clearing the field of moisture and possibly blood. Hence it will be found advantageous to use tampons made by twisting cotton around the end of pieces of wood, a purpose for which the fine cylinders used in preparing matches are especially convenient. These may be cut into pieces six or eight inches long, and a number armed with the cotton are kept in readiness. In this way the loss of time and frequent loss of the field, unavoidable if the cotton must be changed in the ordinary holder, are avoided.

The *pencil* is identical with that used in treating the throat, except that the holder is somewhat longer and straight. The ordinary laryngeal pencil can be adapted for endoscopic use if the shaft be thin and flexible. A tampon can of course be made to supply the place of a pencil.

A *caustic-holder* for the application of bluestone and solid nitrate of silver is a great convenience.

For purposes of medication the various agents commonly employed in the treatment of conjunctival affections may be used. Among these are :

1. Solutions of silver nitrate, the strength varying from one to forty grains to the ounce of water. These are especially valuable in granular and ulcerated conditions of the urethra, and are best applied by means of the pencil.

2. Iodine, either as the tincture or as a solution in glycerine with the iodide of potassium. The following formula is generally useful: Iodine, 1; iodide of potassium, 5; glycerine, 50. This is a useful application in cases of chronic urethritis.

3. Astringents, especially alum, sulphate of zinc, and tannin. The two former can be applied either as solution with a brush or can be blown in as powder; tannin is best applied as a solution in glycerine.

Iodoform is an especially useful application in cases of chronic urethritis.

For the medication of the deep urethra these and other remedies can be conveniently and advantageously applied through the endoscope by means of soluble gelatine bougies, such as are made by Mitchell in Philadelphia.

Cauterization of the urethra can be readily made through the endoscope, more advantageously, indeed, than by any other instrument employed. A stick of the sulphate of copper or of lunar caustic, fixed in the caustic-holder, can be touched directly upon the spot requiring stimulation.

For the removal of exuberant granulations of polyps, a wire snare can be employed. This answers the purpose satisfactorily in the anterior urethra, but is not so successful in the treatment of polyps in the posterior portion of the canal. For this latter purpose an instrument has been devised by Dr. Klotz, which is said to have been quite satisfactory in his hands. It consists of two concentric metallic tubes, the inner one revolving readily within the outer. At the same point, near the visceral ends of the tubes, there is in each an elliptical window. The instrument is introduced so that the polyp projects into its lumen through the two openings; revolution of the interior tube (the edges of whose window are sharpened) then cuts cleanly through the base of the tumor. A full description of the instrument and its application is contained in the *Medical Record*, July 30, 1881.

After this brief sketch of the capacity of the endoscope, I would again express my conviction that the instrument possesses far greater value for practical purposes than is generally believed. For the specialist in the treatment of genito-urinary diseases, it is indispensable; in general practice the cases requiring its employment are comparatively few. The field in which the endoscope renders extremely valuable service and furnishes information inaccessible by other methods is quite limited, but includes nevertheless a class of cases which are by means of it readily cured and without it remain obstinate and even incurable.

It is not asserted that every case of urethral difficulty which has resisted other means of diagnosis and treatment yields readily to the endoscope; nor is it true that all cases in which the diagnosis can be by the endoscope readily established are as readily cured. I have seen cases of gleet which had been treated with injections and sounds, in which, upon endoscopic examination, localized granular urethritis was detected; and which, notwithstanding the use of topical applications applied through the instrument, have not resulted in a satisfactory cure. In such cases the discharge can often be arrested by a few applications, however obstinate it may have been toward injections and sounds; but in the course of a few months, either with or without provocation in the shape of excesses, it re-

appears. Again it is readily arrested, but is apt to return. In these cases of gleet (from granular urethritis) which resist topical applications through the endoscope, I have always found a constriction of the urethra, often of large calibre and detected only by the urethrometer or large bulbous sound; indeed, my examination of the urethra in a case of gleet includes the use of both instruments, urethrometer and endoscope, unless a pronounced stricture is found. If a slight constriction and granular urethritis are both discovered, I treat the latter condition for a time with topical applications and resort to dilating urethrotomy only in those cases in which such treatment proves ineffectual.

The Electric Endoscope.—Within the last few years instruments have been devised whereby the mucous membrane of the urethra and bladder can be inspected when illuminated by an incandescent platinum wire. The idea originated with Dr. Nitze, of Dresden, and was successfully realized by Leiter, a prominent instrument-maker of Vienna. The same principle has been applied, through modifications of instruments, to the illumination and inspection of various other cavities of the body—the larynx, the ear, the vagina, uterus, rectum, œsophagus, and stomach.

In each of these instruments, including those for the inspection of the urethra and bladder, the wire whose incandescence (produced by an electric current) furnishes the illumination is carried into the cavity to be inspected, thereby furnishing an intensity of illumination impracticable by any other means. Each instrument is, moreover, provided with a series of lenses—a microscope of low power, in fact—whereby objects brought within the range of vision appear magnified. This amplifying arrangement, rendered necessary by the construction of the instrument, confers certain disadvantages as well as the one evident advantage of rendering visible objects which would escape the naked eye.

The instrument is a marvel of mechanical conception and execution, but so complicated as to practically vitiate the value derived from the intensity of the illumination secured by it. Furthermore, it is so expensive (costing about $130 in Vienna) that it is beyond the reach of all except the favored few. Whether or not it is capable of affording information in the diagnosis of urethral and vesical diseases which cannot be secured by other means remains to be seen. As yet only very few surgeons have had the opportunity for testing its powers, and these few do not profess to have exhausted its resources.

My own practical acquaintance with the instrument is limited to an observation of its use in the hands of Professor Dittel and Dr. Grünfeld, of Vienna, who, by the way, have been most prominently identified with the practical applications of the instrument (so far as its use in the urethra and bladder is concerned), and have devoted much attention to its employment. Grünfeld, confessedly the most skilful and experienced of endoscopists, was especially zealous in and had most ample opportunities for employing the new instrument. In his hands, as well as in those of Professor Dittel, it was barren of practical results; for notwithstanding its perfection as an instrument, its employment was attended with most serious, and in many cases insuperable difficulties. For purposes of diagnosis and treatment it was indeed far inferior to the simple endoscope illuminated by reflected light. We can indeed imagine certain conditions in which it might furnish valuable information unattainable by other means; but, so far as I am aware, it has not as yet demonstrated such value in practice. Yet it is possible that further experience and a more general use of the instrument may entitle it to a place in the armament of the genito-urinary specialist.

CHAPTER VIII.

DETERMINATION OF THE URETHRAL CALIBRE BY THE URETHROMETER.

The sounds ordinarily used for the exploration of the urethra are capable of detecting only strictures of small calibre, those which seriously encroach upon the lumen of the canal. By means of the acorn-pointed bougies and sounds, strictures of larger calibre which escape detection by the conical and cylindrical sounds can be recognized. Yet even these fail to detect certain pronounced strictures. For the meatus is, as a rule, less capacious than the pendulous urethra, just as every other tube which nature designs for throwing a stream of liquid some little distance is narrowed at its orifice. Now since the instrument which explores the urethra must be small enough to pass the meatus, it is evident that it is too small to detect a stricture of the pendulous portion so long as the calibre of this stricture exceeds that of the meatus. If, for example, the meatus, as often happens, admits only No. 22 or 23 French, while the general calibre of the pendulous urethra is 32, 34, or 36, a sound, even an olive-pointed bougie, necessarily no larger than the meatus, might fail to detect a stricture admitting 24 or 25. An examination with such instruments might therefore give a negative result as to stricture, while as a matter of fact a decided constriction of the urethra might exist at one or more points. The meatus therefore constitutes, in most cases of normal conformation, a barrier to the accurate exploration of the urethral calibre. This obstacle can of course be overcome by enlarging the meatus, but is more readily evaded by special instruments.

In order to explore the calibre of the urethra independently of the meatus, Dr. F. N. Otis, of New York, devised an instrument which he calls the "urethra-meter," but which is generally designated urethrometer. This can be inserted through a narrow meatus and when within the urethra dilated at the will of the operator, the amount of dilatation being registered by an index at the handle. "When introduced into the urethra and expanded up to a point which is recognized by the patient as filling it completely—and yet easily moving back and forth—the index at the handle then shows the normal circumference of the urethra under examination. In withdrawing the instrument, contractions at any point may be exactly measured, and any want of correspondence between the calibre of the canal and the external orifice be readily appreciated. Among the advantages claimed for this instrument are: 1. Its capacity to measure the size of the urethra and to ascertain the locality and size of any strictures present, without reference to the size of the meatus. 2. It enables the surgeon to complete the examination of several strictures by a single introduction of the instrument."

An improvement in this instrument has been devised by Dr. Robert F. Weir, of New York. The improvement consists in the substitution of an

acorn-shaped bulb instead of the oval extremity, thereby increasing the delicacy of the instrument in detecting slight contractions of calibre.

Dr. Otis and others have made numerous measurements of urethræ supposed to be normal, and have deduced therefrom various conclusions as to the normal calibre of the urethra. Dr. Otis finds that the bulbous portion of the urethra, about an inch in length, is usually more capacious than the remainder of the pendulous urethra; that when the urethrometer is introduced into the bulbous urethra, then dilated and gently withdrawn toward the meatus, it becomes necessary to diminish the calibre of the bulb 3 or 4 mm. in the first inch traversed; the calibre of the canal then remains practically unchanged until the instrument reaches the immediate vicinity of the meatus, which is usually decidedly smaller. He states that in 100 cases of supposed normal urethræ, carefully measured with his urethrometer, the calibre of the ante-bulbous portion averaged 32.95 mm., the bulbous portion itself being on the average 35 mm. In 13 of these 100 cases he detected no variation at all in the calibre of the urethra from the bulb to the meatus.

FIG. 4.—Otis' Urethrometer.

Dr. Weir, after numerous examinations, comes to somewhat different conclusions as follows:

The urethral canal is, in the words of Jarjavay, "narrow at the meatus, dilated in the glans, and very slightly narrowed at the termination of the fossa navicularis; then it forms a cylinder nearly uniform to the prepubian angle, where a coarctation is found. It enlarges then to the bulb."

The spongy portion of the urethra is the smallest (except the meatus) and least dilatable portion of the canal.

Normal constrictions (or obstructions) are to be met with in this portion of the canal as small certainly as No. 29, and the means at present employed are insufficient for the distinction of such from "strictures of large calibre."

The healthy urethra in this portion can generally be readily and safely dilated up to an average size of 32 mm.

The normal size of the meatus is from No. 21 to 28.

These conclusions of Dr. Weir are corroborated by Bumstead and Taylor.

Otis, relying upon his measurements, is inclined to regard any constriction of the urethra in the ante-bulbous portion measuring decidedly less than the bulbous portion as an abnormality which calls for division in case the patient complains of obscure symptoms connected with the bladder, urethra, or genital functions. He has at different times, especially in his recent volume upon "Genito-Urinary Diseases and Syphilis," reported numerous cases in which the division of such constrictions has been followed by the relief of symptoms which had persisted in spite of other and ordinary measures of treatment. He maintains, furthermore, that there is a constant relation between the circumference of the penis and that of the urethra. He says:[1] "When the

[1] Loc. cit., p. 441.

urethral contractions are below the calibre of the closed bulb, or when they are numerous and close together, the normal calibre of the canal may be assumed from the circumference of the flaccid penis. When the circumference is 3 inches, the urethra has a normal calibre of at least 30 French; if 3¼ it will be 32; if 3½, 34; if 3¾, 36; if 4 inches, 38; if 4½ inches 40 or more. The correction" (correctness?) "of this proportionate relation has been verified by the author's careful measurement in over one thousand consecutive cases, without meeting with a single exception in infancy, childhood, adult life, or old age."

Combining these two propositions—first, that the calibre of the urethra is practically uniform from the bulb to the meatus, and, second, that this calibre bears a definite ratio (as set forth in the preceding table) to the circumference of the flaccid penis, posterior to the glans—Otis formulates a simple plan of procedure: The calibre of the urethra from bulb to meatus should be made to bear this given relation to the circumference of the penis; a constriction in any part of the pendulous urethra which constitutes a deviation from this ratio should be divided for the relief of obstinate symptoms. The fact that a large sound, even 28 Charrière (15 English), is admitted, does not, according to Otis, preclude the existence of a stricture which may be responsible for annoying symptoms. An instance of Dr. Otis' theory and practice is furnished in the following case:[1]

"T. W——, aged thirty-five, had gonorrhœa fifteen years ago; has had it several times since—the last time, four years ago, coming on forty-eight hours from date of exposure. After the discharge had existed ten or twelve days, he states that he 'stopped it with a powerful quack injection.' Three or four days subsequent to this he began to suffer with a neuralgic pain in the left testicle, the scrotum became tender and red, testicles moved up and down alternately much of the time, and the penis was greatly contracted; there was likewise pain in the groins, described as drawing and sickening, which extended down into his knees and the bottoms of his feet. This continued with varying severity almost without cessation up to February 22d, when he came to New York for treatment. He fell into the hands of an endoscopist, who discovered numerous granular spots deep in his urethra. Applications made at regular intervals for about three months without benefit. An application of carbolic acid to the scrotum gave some relief to his nervous feelings, but this caused vesication and the relief was but temporary. About May 1st he sought the advice of a surgeon skilled in genito-urinary diseases. Slight stricture was discovered near the meatus and several indurated points farther down. A 28 French solid steel sound was introduced, and after some repetition during one month was given to the patient, to be regularly used once in three days until his trouble ceased.

"Went back to his home, some eight hundred miles distant, and pursued the plan laid out for him, but received no benefit. The motion of his testicles was almost constant, and the nervous feeling this induced drove him almost frantic. Compared with it the pains in his groins, knees, and feet were a positive relief. He became very low-spirited and despondent. Early in October his physician advised him to return to New York and put himself under my care. My examination discovered a penis of normal size, three inches in circumference; scrotum greatly relaxed and covered with eczematous scales produced by the carbolic acid; testicles hanging very low. My attention was at once drawn by the patient to the rhythmical contraction of the cremaster muscles, through which a see-saw motion of the testicles

[1] Loc. cit., p. 506.

was kept up, and which constituted his chief annoyance. Bulbous sound 30 French passed the meatus, but was arrested at half an inch, a point to which his greatest sensitiveness during passage of instruments had always been referred. Bulb 28 French passes through and detects another stricture at two inches and still another at two and a half. On Friday, October 17th, at my invitation, the patient was examined by Dr. Coldham, of Toledo, and Drs. Woodruff and Howe, of New York, especially in reference to the spasmodic action of the cremasters. This was very marked and constant, and continued until the patient was placed under the influence of ether by Dr. Howe. I then demonstrated the size and locality of the strictures before mentioned, and divided them in succession with my large dilating urethrotome, after which I passed with ease a 30 French steel sound through all and into the bladder. As the patient emerged from the influence of the ether, it was observed that there was no longer any of the spasmodic action of the cremaster. When he became conscious he stated that he already felt less of his nervous feeling than for many months. He was certain that the right chord had been struck.

"October 8th. Improvement continues. No return of spasmodic action.

"October 20th. Examination with 30 French shows a slight clinging at one-fourth of an inch from the external orifice. Cut this at once and freely with straight bistoury and pass 31 French. The patient, on the following day, expressed his belief that a complete cure had been effected ; that since the final division of the meatus he had not the slightest return of the abnormal sensations and pain with which he had in some degree constantly suffered for the previous four years. Daily introduction of the bulb was kept up in this case until all bleeding ceased, when the patient was dismissed with the promise on his part to inform me by post if he had any return of this trouble. No such information was received."

Dr. Otis' views on the normal calibre of the urethra, the morbid influence of slight constrictions of that channel, as well as on the radical cure of stricture, have been before the profession for a number of years, but have not been very extensively adopted. The explanation appears to lie largely in the fact that comparatively few surgeons have taken the trouble to investigate the results obtained in practice by the application of these ideas. The opposition and hostile criticism so plentifully bestowed seem to be based upon *à priori* theoretical deductions rather than upon failures in practice. In his recent work upon genito-urinary diseases, Dr. Otis mentions numerous surgeons who have given the subject a fair investigation, and who certify to the favorable results obtained in practice by the applications of the principles enunciated.

It is difficult for one who has carefully investigated the anatomy of the urethra in numerous post-mortem examinations to accept the statement that the normal calibre of the urethra is practically uniform from the bulb to the meatus ; and measurements made during life with the urethrometer confirm the general experience of anatomists that the urethra normally and generally presents certain slight constrictions in the pendulous portion aside from that almost invariably found at the meatus. Indeed Dr. Otis' own measurements exhibit the same fact ; for in his table of "measurements of 100 cases of supposed normal urethræ with the urethrometer, the measured difference between the bulbous urethra and the part anterior to it was," in 6 cases, 4 mm.; in 2 cases, 5 mm.; in 2 cases, 6 mm. ; in 2 cases, 7 mm. ; in 1 case, 11 mm.

Since in these cases, as well as in those measured by Dr. Weir and others, there were no symptoms whatever indicating an abnormal condi-

tion of the genito-urinary functions, it must be inferred that these slight contractions are normal and, of themselves at least, incapable of originating any disturbance of function.

Even if there were possibilities for contention as to the relative calibre of the urethra at different portions, there can be no dispute as to the fact that in the vast majority of cases the meatus is decidedly smaller than the average of the canal. It would seem that a contraction at the meatus ought to exert at least as much disturbing influence as a similar contraction posterior to it. Dr. Otis furnishes[1] a table showing the calibre of the urethral orifice in 100 cases in which no inflammatory condition had existed. The circumference of these varied from 13 to 37.5 mm., the average of the 100 being 24.72 mm. "In no case was the urethra, in the 100 cases, below a calibre of 26 mm.—ranging from this to 39—the average being 32.95."

It would seem, therefore, demonstrated by Dr. Otis' own measurements, as well as those of others, that contractions in the calibre of the urethra as well as its orifice are perfectly normal; that they are found in cases where no inflammatory or other abnormal condition of the urethra has existed to originate them; that they are in other words congenital and frequent; and that they occasion no disturbance of function so long as the urethra remains free from disease, notwithstanding the great disproportion of the calibre at these points of constriction to the general size of the urethra and to the circumference of the penis.

When, however, the urethra has been the seat of inflammation, it is quite possible that these congenital and normal constrictions of its calibre, even when so slight as to escape detection by the ordinary instruments of exploration, may aggravate and prolong the affection and induce complications which can be relieved only by the removal of the constriction. In support of this assumption there are certain analogous facts and direct demonstrations.

It is a familiar and unquestioned observation that a decided constriction of the urethra or of the meatus originates complications in the course of urethral inflammation which can be relieved only by the removal of the constriction; many a case of gleet, of dribbling after urination, of neuralgia of the urethra and bladder-neck, has been relieved by the dilatation of a narrow stricture or the division of a narrow meatus. It would seem, therefore, plausible to suppose that a constriction of the urethra, even though it admitted a larger sound than could pass the average meatus, might exert effects similar in kind if not in degree. Dr. Otis has certainly demonstrated that such constrictions, congenital or acquired, may exist and escape detection by any other instrument than one constructed upon the principle of his urethrometer.

Yet the question must be decided, of course, not by *à priori* reasoning, but by actual test in practice. As already stated, this test has not been made so extensively as is required to determine finally and definitely how far these "strictures of large calibre" are to be held responsible for genital and urinary disorders. Dr. Otis himself has furnished a long list of cases in which the division of such constrictions, both in the course of the urethra and at the meatus, has been followed by relief from symptoms which had defied all other methods of treatment; and several other surgeons, notably Dr. S. W. Gross, of Philadelphia, have upon the basis of practical experience indorsed more or less completely Dr. Otis' assertions.

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[1] Loc. cit., p. 421.

My own systematic investigation of this subject began only about four years ago ; and although opportunities for observation during that time have been rather extensive and have convinced me that strictures of large calibre are often responsible for morbid conditions, they have not enabled me to determine to what extent these constrictions are indirectly productive of functional abnormalities of the urinary and genital organs, as maintained by Otis. I have learned to regard the urethrometer as an essential means of diagnosis in many disorders of the genito-urinary apparatus ; indeed, I make it a part of every examination of these organs unless special circumstances forbid. Yet I do not regard every slight constriction which may be discovered as an indication for operation until other means of diagnosis have been employed and other possible abnormalities have been removed by less radical measures. Even cases of gleet are sometimes curable by topical applications without division of urethral constrictions which may be present ; and I have repeatedly seen a gleet continue after the removal of such constrictions and the passage of large sounds, until such topical applications were made.

A careful examination of the urethra in twenty-two men who had never had gonorrhœa nor other urethral difficulty has furnished the following results :

1. The bulbous portion is the most capacious and gradually decreases in calibre from behind forward for about an inch or an inch and a half ; from this point to the meatus the calibre is sometimes practically uniform, but often exhibits slight constrictions which are not constant as to location or size.

2. The narrowest point of the channel (except the meatus) was found in more than half the cases at about the middle of the pendulous urethra.

3. The difference in capacity between the widest portion (the bulb) and the narrowest point (the middle of the pendulous urethra) may amount to five, ten, or even twelve millimetres.

4. There is no constant relation between the general urethral calibre and the size of the meatus ; the latter is sometimes almost as capacious as the urethra (in one instance admitting easily a No. 36 bulb) but usually much smaller (by ten, fifteen, or even twenty millimetres).

In another series comprising sixteen cases I measured the urethra of individuals who had had gonorrhœa one or more times, but were entirely free from gleet and other abnormalities of the urinary organs. I was not enabled to satisfy myself that the urethra in these cases exhibited any marked and constant deviation from the features presented by the cases in the first series who had never had gonorrhœa.

Slight contractions of the urethral channel seem, therefore, to be either congenital and natural or are frequently produced by other influences than gonorrhœa ; they may doubtless result from masturbation and probably from lithiasis also. In every case of urinary or sexual derangement, their existence should be noted ; whether or not such constrictions should be divided is a question which must be decided by their probable relation to the morbid condition as well as by the results of other remedial measures.

Like other methods of examination and treatment, this one has acquired much disrepute from its employment in cases to which it is not applicable. It is unfortunate that the specialist in genito-urinary, as in other diseases, acquires a routine method in diagnosis as well as treatment ; he is prone to the adoption of some one method to the exclusion of all others, and in his zealous application of one ignores others of equal value. The endoscope, for example, has a most valuable field in the diagnosis and

treatment of urethral diseases, a field which can be occupied by no other means or instruments; yet endoscopists have endeavored to crowd into that limited field classes of cases in which the endoscope is either useless, or at least far inferior to other instruments for diagnosis and treatment. The result has been that the profession practically ignores the endoscope; for, having proven the fallacy of the claims made for it in many cases, we are disposed to regard it as equally useless in all—to reason that since it cannot do everything asserted for it, it can do nothing. A similar misconception prevails largely, as I think, with regard to the "strictures of large calibre" whose pathological importance Dr. Otis has been so instrumental in bringing before the profession. The clinical importance of these strictures has been much exaggerated; that is, they have been held responsible not only for some but for all of those cases of obscure and obstinate affections of the urethra and bladder which resist primitive treatment by sounds and injections. The result has been that enthusiastic supporters of Otis' plan of treatment have sought refuge in a real or imaginary stricture of large calibre upon slight provocation, and without a complete investigation as to other morbid factors; and the failure to relieve obstinate symptoms by the division of such stricture in cases where other pathological conditions were present, has brought undeserved discredit upon the entire subject. There can be no doubt that a division of a stricture of large calibre, recognizable only by Otis' or a similar urethrometer, has effected the relief of symptoms which sounds, injections, and the endoscope were powerless to remove; but it is equally certain that such division has been performed in many cases without benefit, simply because the morbid symptoms were dependent upon some other pathological condition. The discredit redounds, of course, not to the method but to the surgeon who insists upon curing all cases of whatever nature by that one method; just as the discredit into which the endoscope has fallen is to be ascribed, not to the instrument itself, but to the folly of those who can see no other cause for urethral symptoms than a real or imaginary granular patch in the mucous membrane.

My own experience has demonstrated the morbid influence of strictures of large calibre and the necessity for their complete division (by Otis' dilating urethrotome) in the following conditions:

1. *Gleet.* That a gleety discharge which has made the usual round among physicians, and has for years resisted medication by injections and the passage of large sounds (12 to 16 English), is often maintained by a slight constriction of the urethral calibre and completely and immediately relieved by the division of such constriction, I have repeatedly demonstrated; in one of my cases which were promptly cured by this method, a No. 17 English sound passed readily into the bladder; in another and unique case (narrated on a previous page) the urethra admitted a No. 22 sound. Yet with the greatest deference for the authority of Dr. Otis, to whom the credit of demonstrating this important relation is chiefly due, I must dissent from his assertion that gleet is *always* a proof of stricture, or as he states it, that "gleet is the signal which nature hangs out to notify the patient and his surgeon that the urethra is strictured at some point." For I have treated a few cases in which I was unable to detect even a slight stricture, and in several others I have seen a gleet continue after division of slight strictures and passage of full-sized sounds. One of these was the following:

A railway conductor, aged forty-one, had had three attacks of gonorrhœa, the last ten months before he consulted me. He had been afflicted

since the last attack with a persistent gleet, which had resisted treatment by sounds and injections in the hands of his physician. After several months of this treatment, during which no abatement of the discharge had occurred, the physician explored the urethra with Otis' urethrometer. It was found that the general calibre was 34, while a constriction to 28 was detected about one and a half inch back of the meatus, the latter measuring 23. This constriction was by means of Otis' urethrotome enlarged to 32, the meatus being also incised to the same extent. The calibre of the urethra was maintained by the daily passage of a 32 sound.

The gleet continued almost as profusely as before. Two months after the operation, the patient consulted me. At that time a 31 French sound passed without difficulty into the bladder, causing some pain at a point two inches behind the meatus. Upon examination with the endoscope, I found the mucous membrane just posterior to the former stricture quite red, slightly granular, and presenting near the median line on the floor of the canal a mass of flabby granulations more than an eighth of an inch in diameter. These were removed by means of the snare, the base touched with a forty per cent. solution of the nitrate of silver, and the surrounding red surface pencilled with bluestone. In less than two weeks the discharge ceased entirely, and up to the present time (about five months) has not returned.

2. *Irritability of the bladder*, manifested by frequent urination, with or without pain. In all of my cases of this category there has been more or less hyperæsthesia of the urethra, and the sound has revealed very sensitive spots in this channel.

3. Various *sexual disorders*, especially those apparently due to hyperæsthesia of the prostate, and manifested by abnormally frequent pollutions and premature ejaculation.

4. *Chronic inflammation of the prostate and bladder* as a sequel of gonorrhœa. The division of constrictions of the meatus and urethra has occasionally transformed an obstinate into a tractable case.

Doubtless the passage of a sound large enough to completely distend the urethra—possible only after the division of such constrictions—contributes largely to the benefit conferred in many of these cases.

In several other instances I have divided slight constrictions and thus rendered the pendulous urethra of uniform calibre throughout, without the slightest perceptible improvement or relief of symptoms which, after the failure of other remedial measures, I had believed to be produced or at least maintained by urethral constrictions. Most of these cases have exhibited irritability and neuralgia of the bladder. The failure to relieve these patients does not disprove the morbid influence of slight urethral strictures in many other cases, but merely demonstrates my error in attributing the symptoms in these instances to such constrictions. However, the operation has rarely produced any serious reaction, and usually permits the patient to resume his vocation in twenty-four hours; I have repeatedly performed it without anæsthesia. Hence in obscure or doubtful cases the division of strictures of large calibre is justifiable as a tentative and diagnostic operation.

My impression in regard to this matter is, then, that the presence of a stricture of large calibre may be the means of prolonging and aggravating various disorders originating in a urethritis; that in every case in which urethral inflammation has occurred (perhaps in others also) which exhibits a refractory behavior toward ordinary therapeutic means, the urethra should be examined as to the possible existence of such constrictions, and

that these, if detected, should be removed. On the other hand, it is doubtless a mistake to suppose that these "strictures of large calibre" constitute the key to all the obstinate and obscure affections of the genito-urinary organs. The exploration of the urethra with an instrument constructed on the same principle as Otis' urethrometer should be recognized as one of the means of diagnosis, but only one, and not a complete and thorough examination in itself. Moreover, the discovery of such a constriction is not of itself a sufficient warrant for urethrotomy, until the symptoms and the effects of treatment indicate strongly that the constriction is the cause of the difficulty.

Catheterization of the Ureter.

This is a measure which might in exceptional cases possess extreme value in diagnosis, possibly in treatment also. The advantages are obvious: it would be a regular preliminary to any operation which might interfere with the functions of a kidney, such as nephrectomy or nephrotomy. The introduction of a catheter into the opposite ureter would enable the surgeon to satisfy himself whether or not the second kidney was present and in a healthy condition; for it has repeatedly happened that after the removal of one kidney the patient has died of uræmia, because, as has been revealed post-mortem, the excised organ was the only kidney present in a condition to discharge its functions. The introduction of the catheter into the ureter might also solve a question in diagnosis which cannot always be decided by the present methods of examination: namely, whether a given fluctuating tumor of the abdomen is a hydronephrosis or an ovarian cyst. Possibly a hydronephrosis could be evacuated in this way. Such a measure would give certainty to a diagnosis as to the presence of a calculus in the ureter; it might even be useful in pushing back the calculus into the pelvis of the kidney, or at least of determining whether or not nephrectomy would be necessary.

Such advantages would undoubtedly accrue from the introduction of the catheter into the ureter if this measure were generally practised. Up to the present time, however, but few have been able to overcome the extreme difficulties which oppose the execution of this plan. Indeed, it has been accomplished only in the female, where the anatomical relations are such as to oppose but little difficulty as compared with the situation in the male. Simon first practised catheterization of the ureter, after dilatation of the urethra. He performed this manipulation on seventeen women, and in all but two cases succeeded in reaching the pelvis of the kidney. Others, however, who endeavored to repeat the operation found extraordinary difficulty even after the urethra was dilated up to 2 ctm. Thus Winckel and Rutenberg failed entirely, the former asserting that he could not even recognize the orifice of the ureter. Moreover, the preliminary dilatation of the urethra constitutes a serious objection to this method, not only because of the necessity for anæsthesia, but also and especially because of the ill effects sometimes consequent thereupon—incontinence of urine, cellulitis, and fatal peritonitis.

The next successful attempt to catheterize the ureter in the female was made by Grünfeld. By means of a short, wide endoscope, the inner extremity of which was closed with glass, Grünfeld was enabled to bring into the field of vision the opening of the ureter, and then to introduce into this a sound of special construction. He has in this way passed a sound into the ureter to the depth of 15 ctm. This method I know by experience

to be extremely difficult; it requires, on the part of the operator, considerable familiarity with the instrument, and much patience and practice in order to distinguish the opening of the ureter from the numerous folds and depressions presented by the mucous membrane. It is impracticable except when the bladder is distended, whereby these folds are obliterated; and the opacity of the urine, aggravated by the cloud of mucus which soon appears as the result of the irritation caused by the instrument, renders this manipulation tedious and uncertain even after long practice.

The simplest and most practicable method yet presented was demonstrated in September, 1881, to the "Versammlung Deutscher Naturforscher" at Salzburg, by Dr. Carl Pawlik. This depends for its execution upon the fact that the trigonum of the bladder in the female—at whose apices the ureters open into the bladder—is distinguishable by both eye and finger through the vagina. Pawlik happened upon this method of sounding the ureters by his observations in cases of vesico-vaginal fistula operated upon in Carl Braun's clinic, where he was assistant. He found that by introducing the finger through a fistula into the bladder, a catheter passed through the urethra could be readily directed into the ureter; subsequently he observed that the finger in the vagina afforded the necessary assistance for the same purpose. As originally practised, the patient was made to assume the knee-elbow position; a Sims speculum retracted the posterior wall of the vagina, so that the operator could both see and feel the projection in the anterior wall corresponding to the trigonum vesicæ. A sound introduced through the urethra was then guided by the finger into the ureter. Subsequently Pawlik found that inspection of the vagina was unnecessary; by placing the woman upon her back in the ordinary attitude for vaginal examination, the finger in the vagina sufficed to direct the instrument in the bladder. Pawlik thus introduced sounds into the ureters in several cases in which Billroth performed the vaginal extirpation of the uterus, thereby affording the surgeon better facilities for avoiding the ureters. In the summer of 1882 Pawlik informed me that he had successfully catheterized the ureter in more than forty cases, having failed only once; this failure was due to a decided prolapse of the uterus.

However simple this method may appear, its successful execution requires, nevertheless, considerable practice and patience. I have performed it repeatedly on the cadaver, but have not always been successful. I use a flexible sound, its bulbous extremity having a calibre of not more than No. 4 Charrière. The instrument is straight except that the last half inch (at the bulbous extremity) is bent at a slight angle with the shaft. With the finger in the vagina the apex of the trigonum is recognized and slightly raised, so that the orifice of the ureter shall rest on the inner side of the finger. The point of the instrument introduced into the bladder can readily be detected, and should be guided so as to enter the orifice. The first attempt will probably be unsuccessful; the point engages in the mucous membrane in the vicinity of the ureter, and the mistake is discovered only when the effort to advance the instrument meets with decided resistance. When finally the instrument enters the ureter, the fact can be ascertained by observing that while it progresses readily in the direction of the ureter, it cannot be moved laterally without decided resistance.

A catheter of appropriate size—not larger than No. 4 or No. 5—can be slipped over the sound after the closed end has been cut off. If it enters the ureter, it usually advances without much obstruction until it reaches the point where the ureter crosses the common iliac artery; here a con-

siderable, sometimes insurmountable, obstacle is offered by the change in direction of the ureter.

While this method is by no means easy of execution, it is practicable, requires no preparation on the part of the patient, and no instruments of special construction. It should be undertaken in every case where its successful execution would be a matter of importance in diagnosis; for even if unsuccessful, the attempt, when carefully and judiciously made, inflicts no injury upon the patient.

The introduction of the catheter into the ureter in the male has not as yet been accomplished; the anatomical relations are such as to offer but little encouragement to the attempt. Various measures have been devised for the purpose of securing the urine from one or the other ureter as required. These measures have consisted in the attempt to obstruct one ureter so as to prevent the escape of urine from it into the bladder; the liquid which then collects in the bladder, being derived from the opposite kidney, affords the means of estimating the condition of this organ.

The first method devised for this purpose was contrived and executed on his own person by Teichmann. He constructed an instrument resembling a light lithotrite; this was introduced into the bladder, the jaws separated and then approximated so as to compress the orifice of one ureter. Although the measure was carried into execution by Teichmann upon himself, apparently with success, it was not adopted by others, for obvious reasons.

Other plans have been tried, based upon the occlusion of one ureter by the pressure exerted over its vesical orifice; one of the most promising of these is that devised by Silbermann, of Breslau. A metallic catheter (No. 18 French) is provided with an opening one and a half inch long upon the side and with several small perforations at its extremity. After the instrument has been introduced, a smaller catheter is passed into it. Over the end of this smaller tube is fitted a rubber bag, which, when the smaller instrument is in position, fills the eye of the outer catheter. This instrument is so placed that the eye rests against the orifice of the ureter; mercury is then poured into the inner tube, dilating the rubber bag and compressing this orifice. It is said that this instrument has been successfully employed in securing the urine from one kidney only; yet there seems to be necessarily an element of uncertainty as to whether the ureter is completely occluded.

In other cases the hand has been introduced into the rectum, the ureter sought out as it passes along the posterior surface of the bladder and compressed between the fingers. This is a tedious manœuvre, not entirely devoid of danger to the patient; and after all it affords no certainty of accomplishing the desired object; for the fingers, which must compress the ureter for ten or fifteen minutes at least, require occasional change of position, during which movement the urine which has collected above the point of compression may possibly escape into the bladder.

CHAPTER IX.

PHYSIOLOGY OF THE URINE.

The kidney is an aggregation of tubules, each of which secretes urine. The study of the process whereby the urine is secreted consists, therefore, in a study of the urinary tubule and its functions.

The tubule is a microscopic canal which begins at the pelvis of the kidney (of which it is indeed a prolongation), extends through the entire breadth of the kidney, and terminates in an expanded extremity in the cortical portion of the organ. The tubule consists of an elastic cylinder, the inner (concave) surface of which is covered with cylindrical epithelial cells, whose broad bases rest upon the elastic basement, while their narrow ends point into the lumen.

The various portions of the urinary tubule have been designated by different names: the first portion—that which proceeds in a straight course from the pelvis to the cortex—is termed the "straight tube of Bellini;" the next segment—that which runs from the cortex into the medulla and then curves back again into the cortex—is called the "loop of Henle;" the terminal segment of the tubule—that which presents a series of short, irregular curves—is designated the "convoluted tubule."

The expanded blind extremity of the tubule is depressed; that is, the blind end of the tube is pushed into its cavity, making a cup-shaped depression, just such as would be produced by pushing the end of a glove finger into its cavity. In this cup-shaped depression rests the bunch of capillaries termed the "Malpighian tuft" or "glomerulus." The depressed, blind extremity of the tubule is closely adherent to the glomerulus, which it almost completely encloses, leaving uncovered only a small space for the entrance of an artery and exit of a vein which carry the blood to and from the glomerulus. This portion of the tubule covering the glomerulus is accordingly termed the "capsule" of the glomerulus (Fig. 1).

The cells lining the tubule differ in form and size in the different segments of the canal. In the straight tube of Bellini and in Henle's loop, distinct cylindrical cells are distinguishable; in the convoluted tubules, on the other hand, the epithelium consists of a jelly-like mass in which nuclei are imbedded at regular intervals, though no separation of the mass into distinct cells is possible.

The cells constituting the blind extremity of the tubule—those covering the glomerulus—are thin, flat scales, apparently identical in form with the endothelial cells which line the serous cavities of the body. They are therefore entirely different in appearance from those constituting the rest of the tubule. They appear to lie directly upon the capillaries of the glomerulus, there being no basement membrane interposed.

The tubule is surrounded throughout almost its entire length by capillary meshes. The branches of the renal artery pass from the hilus of the

kidney between the straight tubules, where they divide into two sets of vessels. One set divide at once into the capillaries which surround the straight tubules; the other set of arteries proceed between the straight tubules to the cortex of the kidney, where each terminates as a glomerulus. The vein emerging from the glomerulus conducts the blood to the network of capillaries surrounding the convoluted tubules. It is thus evident that while all the blood which enters the kidney passes through the intertubular capillaries, only a portion of it reaches the glomeruli.

In this connection it is interesting to note that in certain amphibians there is a marked difference in the blood-supply to the glomeruli and to the tubules; the former receive blood directly and only from the renal artery, while the capillaries surrounding the tubules are supplied also by a renal portal vein, which transfers blood from the alimentary canal to the kidney. Hence, in man as well as in the lower animals, the tubules are supplied with more blood than reaches the glomeruli, since they receive the blood which has passed through these tufts plus an additional quantity which is supplied directly from the renal artery, or from a renal portal vein. This increased blood-supply to the tubules would indicate that they perform a function different from that of the glomeruli—an inference whose correctness has been demonstrated by the researches of the last decade. The blood-supply of the human kidney is derived chiefly, though not entirely, from the renal artery; for there is free anastomosis between the vessels of the kidney and those of its capsule, and this latter is largely supplied with blood by branches of the suprarenal, lumbar, and spermatic arteries. The supply of blood from these sources is quite considerable; for Hermann has shown that the secretion of urine may continue in appreciable quantity even after the renal artery has been ligated, sufficient blood being derived from the suprarenal and spermatic arteries to maintain the function of the kidney. Litten has shown that the spermatic artery alone furnishes an appreciable amount of blood to the kidney; he found that after ligation of the renal artery and vein and of the suprarenal artery, there occurs a transient period of anæmia of the kidney, which is, however, soon followed by decided congestion of the organ and even the formation of infarcts; by ligating the ureter, including the spermatic artery (in addition to the vessels already named), permanent anæmia of the kidney was secured.

The Functions of the Tubule.—The lower portion of the tubule—the straight tube of Bellini—has, so far as known, only the mechanical function of a duct, a channel for the passage of the urine. This part of the tubule seems to be merely the continuation of the ureter.

The remaining portion—the loop of Henle and the convoluted tube—effects the true secretion of the urine. The epithelial cells in this portion of the tubule perform the ordinary functions of a gland, in that they abstract from the blood which circulates around them certain ingredients which are then transferred to the lumen of the tubule.[1]

[1] This secretory activity of the cells lining the convoluted tubules and loops of Henle was first satisfactorily demonstrated by Heidenhain, in 1875. He injected into the circulation a solution of the indigosulphate of sodium, and observed that in the course of a few minutes the urine acquired a blue color, indicating that the indigo was being excreted from the blood by the kidneys. To determine what part of the organ was instrumental in this excretion, Heidenhain killed the animals at various periods after the appearance of the blue tint in the urine, and examined the kidneys microscopically. He found particles of indigo blue in great numbers in the cells lining the convoluted tubules, and in smaller quantity in the cells of Henle's loops, but never in those of the

That these secreting cells separate from the blood not only the solid constituents but also some of the water, must be admitted without actual demonstration, since excretion of solids without water is inconceivable. But Nussbaum has furnished in the following way an elegant demonstration of the fact that the cells of the tubule separate from the blood some of its watery constituents: in amphibians, the Malpighian tufts are supplied with blood by branches of the renal artery, while the capillaries surrounding the urinary tubules obtain an additional supply from the renal portal vein. Ligature of the renal artery, therefore, while cutting off the blood-supply of the Malpighian tufts, does not deprive the tubules entirely of blood. Nussbaum observed that ligature of the renal artery in amphibians was followed at once by a suppression of the urinary secretion; but he found that this secretion commenced again in appreciable quantity after an injection of urea into the blood of the animal, even though the ligature on the artery remained undisturbed. It is evident, therefore, that the well-known diuretic effect of the urea was sufficient in this case to stimulate the cells of the tubules to a considerable excretion of water.

The functional activity of these cells appears to be limited almost entirely to excretion, since nearly all of the materials found in the urine are produced in the body without the intervention of the kidneys, and exist preformed in the blood of the systemic circulation. The kidneys, like other organs, produce urea and uric acid, but only in relatively small quantity. There is, however, one substance which is produced chiefly, if not entirely, by the secreting cells of the kidney—hippuric acid. The recent researches of Bunge and Schmiedeberg have demonstrated that benzoic acid is transformed into hippuric acid in the living animal by the kidneys; indeed, they were able to secure this transformation in extirpated kidneys by passing through the excised organs blood containing benzoic acid.[1]

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straight tubules, nor in the capsules of the glomeruli. It was thus demonstrated that the cells of the convoluted tubules and of Henle's loops possess the power of separating one substance at least from the blood. Subsequent research showed that the urates and the biliary pigments also are excreted by these same epithelial cells; and it is assumed that all the other solid ingredients of the urine are abstracted from the blood by the activity of these same cells.

Since the publication of Heidenhain's researches, numerous investigators have confirmed his results. It has been found, furthermore, that the injection of certain substances, such as chromic acid and cantharides, is followed by necrosis of the cells in the convoluted tubules, while the remainder of the kidney remains unaffected. This fact also demonstrates the secretory activity of these cells, which abstract the chromic acid from the blood, and are thereby rendered necrotic; while the cells lining the rest of the tubule, because they possess no secretory activity, experience no damage from the toxic agent

[1] Attempts have been made to ascertain whether or not this power of the kidney to transform benzoic acid into hippuric acid is impaired in various renal affections. Jaarsveld and Stokvis assert, as the result of both clinical and experimental observation, that such impairment does occur, and can perhaps be made a factor of diagnostic importance in the recognition of kidney diseases. These observers induced hæmoglobinuria and nephritis in rabbits by the injection of glycerine; they found that such animals excreted no hippuric acid. Benzoic acid administered to these rabbits appeared in the urine unchanged; while healthy rabbits to which benzoic acid was administered excreted in the urine none of this substance, but a corresponding quantity of hippuric acid. Extending their observations to the bedside, Jaarsveld and Stokvis found that the excretion of hippuric acid was diminished in certain cases of renal disease as follows: In two cases of parenchymatous nephritis, one acute and one chronic, no hippuric acid was found in the urine; benzoic acid administered by the mouth appeared in the urine unchanged. In two other cases of the same affection, the excretion of hippuric acid was markedly decreased; also in two cases of amyloid degeneration

The Functions of the Glomerulus.—The anatomical structure of the glomerulus indicates its physiological function; it seems to be a purely mechanical apparatus for the separation of the watery constituents of the blood by filtration. It is so arranged that the blood exerts upon the walls of the capillaries composing the glomerulus much greater pressure than is exerted upon the capillaries elsewhere in the body. This arrangement consists merely in the division of the arteriole—the vas afferens—into a large number of capillaries, which subsequently reunite into a single small vein—the vas efferens. Since the calibre of this efferent vein is much less than the combined calibre of the capillaries which empty into it, there must necessarily occur an unusually great pressure on the walls of these capillaries. To favor the process of filtration still more, unusually slight resistance is offered to the escape of fluid from the capillaries of the glomerulus, since the blood in them is separated from the lumen of the tubule only by the capillary wall and the layer of delicate cells covering the glomerulus. Under such conditions a much larger percentage of the watery elements of the blood must necessarily escape. In all the capillaries of the body a certain amount of the blood serum passes through the vascular walls; from those of the kidney not less than fifty ounces of fluid usually escape during the twenty-four hours.

The separation of the water (and of the salts which naturally accompany it) is generally regarded, therefore, as a process of purely mechanical filtration. Upon this assumption we can understand the variations in the quantity of urine observed in clinical and experimental cases. The quantity of water filtered through the glomeruli, and hence of the urine, will be increased by any one or more of the following factors:

1. *Increase of blood-pressure in the glomeruli.* This may be due either to increase of the general arterial pressure, or to obstruction to the return of blood through the renal vein. Digitalis, for example, causes an increased secretion of urine by raising the general blood-pressure in the arteries and hence in the glomeruli. Obstruction to the return of blood from the kidney rarely occurs clinically except as a result of enfeebled action of the heart; a few cases are, however, on record in which a local impediment existed which interfered with the circulation through the renal vein without affecting the general blood-pressure. In these cases an increased secretion of urine has been observed.

2. *Increased rapidity of the blood-current through the glomeruli.* This usually occurs as an accompaniment of increased blood-pressure, since the influence which increases the pressure usually increases also the rapidity of the circulation. Yet we know from the laws governing filtration of fluids, that the effect of increased rapidity is, *cæteris paribus*, to increase the rapidity of filtration.

3. *Dilution of the filtering fluid.* The ingestion of large quantities of water is followed by a profuse secretion of urine. This results not from an increase of blood-pressure (because no such increase occurs), but simply from the increased diffusibility of the circulating fluid.

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of the kidney. In three cases of cirrhosis and one of venous congestion, on the other hand, the excretion of hippuric acid was unimpaired, benzoic acid administered by the mouth undergoing the same transformation as occurs in healthy persons. Although the number of these observations is too small to justify a conclusion, they certainly afford a presumption that the excretion of hippuric acid by the kidneys may become an important item in determining whether or not the renal epithelium is affected in cases of kidney disease, or whether the affection is limited to the interstitial connective tissue and the blood-vessels—in other words, whether the nephritis is parenchymatous or interstitial.

4. *Increased permeability of the capillary walls.* Upon this point we have but little definite knowledge. It is known that an increased flow of urine often occurs in cases of pure amyloid degeneration of the kidney; and it is also known that this degeneration affects especially the capillaries of the glomeruli; hence the inference that these degenerated capillary walls offer less resistance to the escape of the contained fluid.

That a thickening of the filtering membrane would retard the escape of water from the blood is not only plausible, but is actually demonstrated in the nephritis which follows scarlet fever. During this affection the quantity of urine excreted is much diminished; indeed, temporary anuria may occur. The reason for this is apparent upon microscopic examination of the inflamed kidney, which reveals a proliferation and thickening of the flat cells covering the glomerulus, and a thickening of the capillary walls.

There are cases in which variation in the quantity of urine secreted seems inexplicable by the laws of simple filtration. Thus in many instances an increased secretion of urine seems to result directly from nervous influence; such is the polyuria which usually follows a hysterical attack or an epileptic convulsion. It seems highly probable, however, that the nervous influence affects the kidney not directly, but indirectly through the splanchnic nerves, whereby the calibre of the renal arteries is increased and a greater amount of blood circulates through the kidney. It is at any rate demonstrated that the amount of urine secreted can be increased by puncture of the floor of the fourth ventricle, whereby (through the agency of the splanchnic nerves) the circulation of blood through the kidney is increased.[1]

In the present state of our knowledge, therefore, we must regard the urine as the product of two distinct processes: 1, *the specific activity of the cells* lining the convoluted tubule and the loop of Henle, whereby the solid ingredients of the urine and some water are separated from the blood; and, 2, *filtration through the glomeruli*, whereby the liquid ingredients and certain salts escape from the blood.

It seems with our present knowledge that the solid constituents of the urine—urea, uric acid, creatinin, etc.—never escape from the blood in appreciable quantity through the glomeruli; their presence in the urine indicates and measures the functional activity and integrity of the epithelial cells of the tubules. The excretion of water from the blood, on the other hand, is not monopolized by the glomeruli; a certain amount is separated under ordinary circumstances by the secreting cells of the tubules, and this amount can be, under extraordinary circumstances, much increased. The experiment of Nussbaum, already related, shows that the presence of urea in the blood stimulates these cells to the secretion of considerable water; it is possible that the diuretic effect of certain salines is exerted in like manner through the cells of the tubules, rather than through the glomeruli.

[1] Heidenhain has recently argued upon theoretical grounds that the escape of water from the glomeruli is not a purely mechanical process, but is influenced largely by the activity of the cells covering the tufts. The considerations advanced in support of this view seem by no means convincing.

CHAPTER X.

PATHOLOGY OF THE URINE.

The solid constituents of the urine comprise almost all the products of decomposition of the albuminous substances contained in the tissues. So long as the kidneys perform their function properly, but little of these albuminous products escapes through the skin, lungs, and intestine. The urine is therefore an index to the metamorphosis of the albuminous ingredients of the tissues. Conversely, so long as the other organs of the body perform their functions normally, the solid constituents of the urine constitute an index to the activity of the kidneys.

Yet not all of the solids found in the urine are to be regarded as the products of tissue metamorphosis; for materials introduced by the mouth, such as egg albumen, are rapidly eliminated by the kidneys, and substances produced in the small intestine, such as indican and carbolic acid, are separated from the blood by the same organ. Even the excretion of urea —which is pre-eminently a product of tissue metamorphosis—varies largely according as much or little nitrogenous food is consumed. Hence a proper interpretation of the information derived from an analysis of the urine must be based upon a knowledge of the individual's general condition, diet, etc.

Variations in the Normal Ingredients of the Urine.

Normal urine may be regarded, for practical purposes, as a solution of urea and of the chloride of sodium. These three chief ingredients—water, urea, and chloride of sodium—are accompanied in their exit from the blood by certain other solid ingredients of that fluid, organic and inorganic, as well as by various foreign matters which have been introduced into the organism.

For clinical purposes the most important ingredients of normal urine are the following; the average amount excreted daily (according to Salkowski) is also given:

	Grammes.
Urea	25.00 to 35.00
Carbolic acid	0.02 to 0.05
Indican	0.06 to 0.08
Urobilin	Undetermined.
Chlorides	10.00 to 15.00
Earthy phosphates	0.80 to 1.40
Alkaline phosphates	2.50 to 3.50
Sulphates	1.50 to 2.50

Urea.—This, the chief solid ingredient of the urine, is derived exclusively from albumen. Whether or not it is formed directly from albumen, or indirectly after existing in the shape of other compounds, is still an unsettled question. The attempts to produce urea artificially by direct oxidation of albumen have failed, though a substance very similar to urea—guanidine—has been produced by the action of the permanganate of potassium upon albumen (Béchamp, Ritter). It seems probable that urea is formed in the body not directly from albumen, but from one of the substances which arise from the decomposition of this. Schultzen and Nencki have shown that albumen is changed in the organism into fatty acids, and that these are transformed into urea; yet it is by no means certain that most of the urea is produced in this manner. It has been shown by Frerichs, Stokvis, and Neubauer, that uric acid introduced into the stomach is transformed and excreted as urea. Probably some of the uric acid produced in the organism as the result of tissue change is likewise oxidized into urea. Leucin taken into the stomach is entirely converted into urea; hence it is considered certain that the leucin naturally produced in the tissues from the metamorphosis of albuminous substances is normally transformed and excreted as urea. This transformation seems to be effected by the liver.

It is quite possible, and indeed probable, that urea originates in still other ways in the organism.

Many attempts have been made to ascertain where and by what organs the transformation of these various intermediate albuminous substances into urea is accomplished. The classical and often-repeated experiment of Prevost and Dumas—the extirpation of the kidneys—shows that these organs have little if any agency in the production of urea; for this substance is produced in the usual quantity after the kidneys have been removed.

Urea is constantly found in certain tissues of the body, particularly in the liver, the lungs, and spleen; it is also constantly present in the blood, lymph, aqueous humor, and serous fluid. There is, indeed, one reason for believing that the organs named are largely concerned in the production of urea: this reason is the generally admitted absence of urea from the muscles; although one would suppose that the muscular system—so extensive and so rich in albuminous matters—would necessarily furnish much of the urea, yet no trustworthy observer has as yet been successful in detecting this substance in the muscles of healthy animals. Voit, it is true, found that the muscles of a dog from which the kidneys had been removed contained more than twice as much urea as the blood, and hence believes that the muscles must, at least under these abnormal conditions, produce urea. So too it has been found that the muscles of patients dead from cholera contained urea in appreciable quantity—in fact, more than the blood.

The absence of urea from the muscles and its constant presence in the liver and spleen indicate that the latter organs are instrumental in producing this substance. All observers have found the liver especially rich in urea, and have usually observed that it contains a larger percentage of this substance than the blood. A fact first observed by Frerichs, and subsequently confirmed by others, points strongly to the same conclusion: he noticed that in a case of acute yellow atrophy of the liver, the urea found in the urine was much decreased in quantity and even disappeared entirely, while on the other hand certain intermediate products in the decomposition of albumen—leucin and tyrosin particularly—were excreted.

Ratio between Tissue Metamorphosis and Urea.—The quantity of urea

excreted in the urine varies in different conditions of health and disease; and since it is a product of the decomposition of albumen, many efforts have been made to discover and determine for pathological purposes a quantitative relation between the amount of this substance found in the urine and the decomposition of the nitrogenous elements of the tissues. The actual amount of urea excreted in the urine cannot, of course, represent accurately the albuminous decomposition, because, first, only a part of the urea formed in the body is excreted by the kidneys, the remainder being eliminated by the skin, intestine, and lungs; second, urea is only one of several substances into which the nitrogenous elements of the tissues are decomposed; hence its quantity does not fully represent the amount of such decomposition; third, much of the urea excreted is derived directly from the food and not at all from tissue waste.

Yet it has been found by Voit that an approximately accurate index to the decomposition of albuminous substances in the body is furnished by the urea and other nitrogenous matters excreted in the urine. It has been ascertained that 100 grms. of muscular tissue separated from its fat and connective tissue contain about 3.4 grms. of nitrogen, corresponding to 7.28 grms. of urea. Every gramme of urea found in the urine would therefore represent a decomposition of 13.72 grms. of muscular tissue (or its equivalent of other tissue).

Nitrogen Equilibrium.—Urea is excreted so long as life persists; in starving animals there is an appreciable excretion even until death. If a fasting animal be supplied with nitrogenous food, an unexpectedly large excretion of urea is observed. For it is found that the urea excreted represents not only the albuminous substances of the food, but also almost as much body waste as occurred during the period of fasting. The latter quantity is, however, a trifle less than formerly, and thus there occurs a gradual accumulation of albuminous materials, and hence increase of weight in the body. This repair continues until the body weight is restored to its normal figure, after which the quantity of urea excreted corresponds exactly to the amount of albuminous materials in the food.[1]

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[1] Thus a fasting dog excretes, say, 10 grms. of urea per day; since each gramme of urea results from the decomposition of 13.72 grms. of albuminous tissue, the animal is losing 137 (10 × 13.72) grms. of flesh per day. Now if this amount—137 grms.—of meat be administered to the dog daily, we would expect that it would be used to supply the loss, and that as a result the body waste would cease at once, while the daily excretion of urea would remain 10 grms. Such is, however, not the case; the excretion of urea becomes almost (though not quite) double what it was during fasting—say 18 grms; this represents the urea formed from the food (10 grms.) plus that derived from the tissues (8 grms.). The daily loss of flesh is diminished, but does not cease entirely. If now the quantity of food be doubled, that is, if 274 grms. of meat be given, the amount of urea excreted becomes about twenty-five grammes—that is, 20 grms. from the food and 5 grms. from the tissues. This amount of food is therefore not sufficient to replace the albumen consumed in the tissues—the animal continues to emaciate. When the amount of food is increased so that it alone furnishes about *four times* as much urea as the fasting animal excretes, the dog ceases to emaciate, and it is found that the urea excreted now corresponds exactly to the amount consumed with the food. The animal's weight remains unchanged from day to day. This is "nitrogen equilibrium."

By still further increasing the amount of food, it is found that during the first few days the quantity of urea excreted is less than that contained in the food—in other words, some of the albuminous constituents of the nourishment are stored away in the body. After some days, however, the equilibrium is again restored—*i.e.*, the amount of urea excreted equals exactly the quantity supplied by the food.

If, on the other hand, the quantity of food administered to a well-nourished animal be suddenly diminished, it is at first observed that the urea excreted represents more albuminous matter than the food contains; in other words, the tissues lose a certain

It follows from these facts that the healthy organism possesses a certain accommodative power, by virtue of which it is enabled within certain limits to adapt its consumption of albumen to the amount supplied, whether this be large or small; so long as the bodily functions are normally performed, the amount of albuminous constituents excreted is just equal to that supplied by the food. The minimum amount of nourishment required to sustain this "nitrogen equilibrium" must contain much more nitrogen than is actually consumed by the tissues—probably about four times as much. It is further evident that the quantity of urea contained in the urine affords no clue to the amount of tissue metamorphosis, unless the quantity of albumen contained in the food is also known.

Quantity of Urea Excreted.—From what has been said, it is evident that the excretion of urea may vary in the same healthy individual from day to day according to the kind and amount of food consumed. Hence observations made upon different classes of people have given divergent results. Voit and Rubner found that the average daily excretion of urea in well-nourished German laborers was 30 to 35 grms. This was at the rate of .5 to .6 grms. for each kilogramme of body weight. In corpulent individuals the percentage is somewhat small, since the excess of body weight in such persons represents an accumulation of fat rather than albuminous tissues. The percentage is less in females than in males, but much higher in children than in adults.

Clinical Estimation of Urea.—For clinical purposes the determination of the quantity of urea excreted in the urine has seldom much value *as an index to the amount of tissue metamorphosis.* For since the urea is furnished not only by the decomposition of tissues but also directly by the food, the quantity derived from the tissues can be ascertained only when that furnished by the food is estimated. Such procedure is too complicated for clinical purposes; hence the determination of urea is practically valuable only under certain circumstances.

Thus in acute febrile diseases the patient rarely receives any considerable quantity of nitrogenous food; hence the amount of urea excreted—being derived almost exclusively from tissue waste—represents fairly the amount of this waste. Yet even here we are not sure that all the urea produced is excreted; in fact, we know some circumstances which retard the elimination of urea through the kidneys. Among these are the retention of water in the blood—a usual occurrence in febrile conditions; the formation of transudations in the subcutaneous tissue and in the serous cavities (for these transudations contain urea and albumen); abnormally low arterial pressure, as occurs in typhoid and typhus fevers; profuse perspiration, copious diarrhœa, inflammation of the kidney—all divert urea from the urine. On the other hand, there are various circumstances which may cause an increased amount of urea to appear in the urine, without any increase in tissue metamorphosis; thus active diuresis, whether from the ingestion of water or from a rise of blood-pressure, may result in washing out of the blood urea which had accumulated in this fluid. So, too, the resorption of transudations brings into the blood a considerable amount of albumen contained in the transuded fluid. This albumen is at once transformed into urea, and being excreted by the kidneys, raises considerably the amount of urea contained in the urine,

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portion of their nitrogenous constituents. This relation lasts, however, but a few days, after which period the urea excreted corresponds to the diminished amount of nourishment.

though there has been no increase in tissue metamorphosis nor in the quantity of nitrogenous food ingested.

If therefore we are to derive accurate and reliable information *as to the amount of tissue change* from the quantity of urea excreted by the kidneys, we must eliminate the possible sources of error already enumerated by taking into account the influences other than tissue waste whereby the excretion of urea is affected ; but this is practically impossible.[1]

It is *as an index to the secretory activity of the kidneys* that the determination of the urea often furnished important information ; for, since the excretion of urea is performed by the renal epithelium, the deficit in the amount excreted in cases of renal disease indicates *in a general way* the degree of impairment of the renal function. Yet only in a general way ; to secure even approximate accuracy, it is necessary to compare the urea excreted by the patient with that excreted by a healthy individual nourished upon the same diet and exposed to the same conditions of exercise, clothing, temperature, etc. Such comparison is in private practice at least usually impossible. Hence the determination of urea as an index to the condition of the kidney is practically valuable only when the quantity is found upon repeated examination to be markedly less or more than the average amount excreted by healthy persons.[2]

Factors which Influence the Production and Excretion of Urea.—The quantity of urea which appears in the urine can be perceptibly increased without augmenting the amount of albumen in the food, by various measures which increase tissue change. The *administration of phosphorus* —in doses sufficient to cause death in eight or ten days—augments the quantity of urea excreted to three or four times its normal amount. Other

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[1] Fortunately we may often derive valuable information *by comparing the quantity of urea with that of the common salt excreted* by the kidneys. For it is found in healthy individuals the salt excreted amounts to about one-half by weight of the urea in the same urine. Now since the salt is derived chiefly from the food, a comparison of the two shows whether the urea is derived largely from the food or from the tissues ; for if an increase in the quantity of urea excreted is accompanied by a corresponding increase in the quantity of salt eliminated, the inference is that the urea is derived largely from the food ; if the quantity of salt be, on the contrary, much less than normal, an excess of urea indicates an excessive tissue change. In fever the quantity of salt excreted in the urine is very small, partly because but little salt is contained in the food, and partly because there is an actual retention of salt in the tissues during fever. Since during convalescence from fever a considerable portion of the albumen of the food is retained in the tissues for restoring them to the normal condition, while the chloride of sodium is not thus needed nor retained, it often happens that during convalescence the quantity of salt in the urine may closely approximate or even equal that of the urea.

[2] Here too *an estimation of the chlorides* in the urine may afford valuable information. These salts probably escape from the blood by simple filtration with the water through the glomeruli and not by the secretory activity of the cells ; at any rate it is well established that the chlorides are excreted quite as freely in the various forms of chronic nephritis as by healthy kidneys. Now in health the quantity of chlorides in the urine is usually about half that of the urea ; hence if, in a case of chronic Bright's disease, the quantity of chlorides in the urine is constantly more than one-half that of the urea, we may infer that the latter substance is not completely excreted—in other words, that the integrity of the kidneys is impaired.

It is interesting to note that variations in the excretion of urea in Bright's disease are accompanied by similar variations in the excretion of phosphoric and carbonic acid. Fleischer found furthermore that phosphoric acid administered by the mouth was excreted less readily by diseased than by healthy kidneys, though no such difference was observed in the excretion of other salts—bromide and iodide of potassium, for example. The quantitative estimation of phosphoric acid in the urine is, however, so complicated a process that the fact mentioned has but little clinical value.

substances, among them *arsenic* and *alcohol*, exert a similar though less pronounced effect.

Limitation of the oxygen inspired increases also the excretion of urea. This has been demonstrated by Fraenkel, who diminished the quantity of air inspired by constricting the trachea in dogs. He found that the urea excreted rose to three or four times the normal amount. Pathological states accompanied with dyspnœa in the human subject also exhibit increased excretion of urea.

Poisoning with carbonic acid also augments the amount of urea excreted —probably, as Fraenkel suggests, by diminishing the quantity of oxygen supplied to the tissues. *Loss of blood* induces the same result, apparently because it decreases the amount of oxygen distributed to the tissues.

Artificial elevation of temperature, by exposure to a warm bath or warm air, has been observed to increase the amount of urea excreted. Schleih found that after one hour's immersion in a hot bath whereby his temperature rose to 39.5° C., the quantity of urea excreted was increased more than thirty-three per cent.

Diuresis favors, of course, the excretion of urea; the increase does not, however, appear to be the result of an augmented tissue change, but occurs simply from the more thorough removal of the urea from the tissues.

The *consumption of animal food* naturally increases the amount of urea formed as well as excreted.

Diverse results have been obtained in the effort to answer the question whether or not *excessive muscular action* causes an increased production and excretion of urea. Voit, Fick, Wislicenus, and Vrietzke were unable to find any increase of the urea in the urine after prolonged and excessive exercise. Flint, Parkes, Schenck, and recently North, on the other hand, observed a marked increase under similar circumstances. The diversity of these results seems to be explained by later observations. Kellner observed that the urea excreted by horses fed upon a diet rich in nitrogen increased decidedly after prolonged exercise; but that when the diet consisted chiefly of hydrocarbons, but slight increase was observed. The explanation appears to be that muscular activity requires the consumption of fats and hydrocarbons; so long as these are supplied in sufficient quantity the nitrogenous tissues are not consumed; when, however, there is a dearth of hydro-carbonaceous materials, the albuminous substances in the tissues are consumed, and a corresponding increase occurs in the urea produced and excreted.

A second moment serves to reconcile the conflicting results above mentioned. Oppenheim found that muscular activity, accompanied with dyspnœa, was followed by decided increase in the excretion of urea, while the same amount of work performed so deliberately as not to embarrass the respiration, did not increase the excretion of urea. Hence he infers that the excessive production of urea observed during muscular activity is the result, not of this activity, but of the imperfect supply of oxygen accompanying it, which, as already stated, is known to be a sufficient cause for an increase in the production and excretion of urea.

The observations of Senator and of Bauer upon cases of tetanus, and of Fleischer upon a case of mercurial convulsions, show that in these conditions, notwithstanding the enormous amount of muscular exertion, no increase in the excretion of urea occurs.

No agent, physiological or medicinal, is known, whereby the amount of urea produced in the body can be much decreased. Fraenkel found that the respiration of condensed air decreased slightly the production of

urea, while the substitution of rarefied air had, as might be expected, the same effect as the abstraction of oxygen—a slight increase in the amount of urea produced.

Excretion of Urea in Disease.—In febrile conditions, from whatsoever cause, the excretion of urea is almost invariably increased. This increase is observed during the height of the fever in most instances, but is sometimes noticed before the rise of temperature begins. In many cases this increased excretion continues also for some time after the critical fall of temperature; this is especially often noticed in cases of croupous pneumonia.

It has been observed that after the administration of quinine, in cases of continued fevers, the interval of reduced temperature is accompanied by an excessive excretion of urea. It is further found that fever induced artificially by the injection of putrid materials is (like the clinical septicæmia and pyæmia), accompanied also by an increased excretion. Surgical operations do not *per se* affect the production of urea; but the occurrence of fever, even if it be only the aseptic wound fever, is accompanied by an increased production.

The only acute febrile condition, aside from renal disease, in which the urea excreted is less than normal, is acute yellow atrophy of the liver; in this disease the urea may entirely disappear from the urine. In non-febrile conditions there is great diversity in the behavior of urea; in many cases accompanied by anæmia there is an increased production, corresponding to the observation that a similar increase occurs after artificial or natural hemorrhage. In pernicious anæmia and leucocythæmia the excretion of urea is often excessive. The greatest excretion occurs in diabetes mellitus; here there is not only an unusually large consumption of albuminous food, but also an excessive metamorphosis of the albuminous constituents of the tissues. The result of this double production of urea is the excretion of an enormous amount, sometimes 125 or even 150 grammes per day. Epileptic attacks are also followed by an increased excretion of urea—due doubtless in part to the diminished supply of oxygen which occurs as a feature of the attack.

Resorption of exudates and transudates, such as dropsical fluids, brings into the blood a quantity of albumen, which is transformed into urea and excreted, thus increasing the total amount found in the urine. An increase in the excretion of urea by a dropsical patient with Bright's disease does not therefore necessarily indicate an improvement in the renal functions.

In cases of gout, chronic rheumatism, biliary colic, and various diseases of the liver, the excretion of urea is diminished. In various hepatic diseases this diminution in the urea excreted is accompanied by an increased excretion of intermediate products, particularly uric acid. In such disorders, therefore—of the liver, bile-ducts and duodenum—the urine is often loaded with urates.

It has been repeatedly noticed that the development of cancer is accompanied by a decided fall in the excretion of urea; in one case the amount fell from 29 to 7 grammes in twenty-four hours. It has been proposed to utilize this observation for diagnosis in cases of suspected cancer of internal organs.

It is evident from the considerations mentioned in the earlier part of this chapter, that but little value can be attached to many observations on record as to the excretion of urea, since in but few cases have the conditions necessary to accuracy of observation been fulfilled.

While in the conditions already mentioned the diminished excretion seems to depend upon a diminished production of urea, there are others in which there appears to be the usual production, but a failure to excrete; these are especially cases of renal disease. Sir Andrew Clark has recently described under the name "renal inadequacy" a class of cases in which the excretion of urea is habitually less than normal, though there is no evidence of kidney disease. Uric acid and urates are also deficient, the urine having a low specific gravity. This condition is usually observed in high livers and is corrected by regulation of the diet.

Hippuric Acid is also a constant ingredient of the urine in man, though it occurs in much smaller quantity than in that of herbivorous animals. It is produced, in part at least, by the decomposition of albumen; under the influence of pancreatic juice there is produced in the alimentary canal a substance which is absorbed and in the circulation is oxidized to benzoic acid; this is subsequently transformed (by a combination with glycocoll) into hippuric acid. The benzoic acid which is contained in vegetables and fruits, such as cranberries and plums, or administered by the mouth, is similarly changed into hippuric acid.[1]

Carbolic Acid.—The putrid decomposition of albuminous bodies—putrefaction—produces numerous aromatic substances. This decomposition is constantly occurring in the lower portion of the small intestine; the putrid products are in great part expelled with the fæces, yet a small portion is absorbed by the intestine.

Among the products of this albuminous decomposition in the bowel are two substances which are subsequently eliminated by the kidney, and sometimes possess great clinical significance. These are phenol (carbolic acid) and indol (the source of indican).

Although normal urine contains no trace of carbolic acid, either free or combined directly with an alkali, yet there is present in every urine a certain quantity (.01 to .05 gramme) of the acid derived from the intestine, and combined with sulphuric acid as a *sulphocarbolate of potassium*. Carbolic acid taken into the stomach or injected under the skin also appears in this form in the urine.

Circumstances which favor the decomposition of albuminous substances in the intestines, as well as those which impede the evacuation of the fæces, must, of course, favor an increased absorption of carbolic acid. Accordingly it has been observed that ligature of the intestine in dogs and intestinal obstruction in the human subject is followed by an increased elimination of carbolic acid (in combination) in the urine.

Carbolic acid is, as is well known, a toxic agent; the combination in which it appears in the urine—the sulphocarbolate of potassium—is, on the other hand, innocuous. So long as the blood supplies sufficient sulphuric acid for the formation of the sulphocarbolates, the carbolic acid which may

[1] One of the most interesting physiological facts established in recent years is the demonstration by Bunge and Schmiedeberg, that this formation of hippuric from benzoic acid is accomplished by the cells of the kidney. They found that after the extirpation of the kidneys or the ligature of the renal vessels in dogs, these animals lost the power of converting benzoic into hippuric acid; ligation of the ureters only, on the other hand, did not interfere with the production of this acid. The same transformation was effected by passing blood containing benzoic acid through freshly excised kidney. After the lapse of some hours the excised kidneys lost this power. It is therefore demonstrated that the kidney cells are the agents whereby benzoic is converted into hippuric acid. These observers found that the addition of quinine to the blood prevented this transformation (probably by destroying the protoplasm of the renal cells); carbonic acid had a similar effect.

be absorbed, either from the intestine or from the surface of a wound, is neutralized by a combination into the harmless sulphocarbolate. So soon, however, as the amount of carbolic acid absorbed is more than enough to combine with the sulphuric acid contained in the blood, an excess of the former must remain as free acid, and exert its injurious effects. It is hence evident that an examination of the urine reveals the approach of danger from carbolic acid poisoning in those who are employing this agent either internally as a medicine, or externally as a dressing. So long as the urine contains an appreciable amount of sulphuric acid (and sulphates) it may be assumed that there is no danger from the carbolic acid; while the disappearance of the sulphates from the urine indicates that the blood is saturated with carbolic acid, and that no more of this substance can be absorbed without danger to the patient. Baumann ascertained that the amount of available sulphuric acid in the blood can be materially increased by the administration of the sulphate of sodium; hence this salt may be properly administered as an antidote to carbolic acid poisoning, present or prospective.

Excretion in Disease.—As yet but few observations on the pathological significance of carbolic acid in the urine have been made. An increased excretion has been observed in cases of inactivity and obstruction of the intestine, intussusception, peritonitis, perityphlitis, atony of the bowel. Since, moreover, the absorption into the blood of the products of albuminous decomposition from whatever source is followed by the excretion of the acid by the kidneys, there occurs an increased elimination in cases of pulmonary gangrene, putrid bronchitis, empyæma, dilatation of the stomach with fermentation, cancer of the womb, rectum, breast, etc.[1]

INDICAN.—Normal urine contains a substance which, upon the addition of hydrochloric acid, exhibits a blue color identical with that of indigo. This indigo-producing substance has long been known and has been termed indican. Only recently, however, has its origin and composition been ascertained (by Baumann and Brieger).

Indican is derived from indol, which, like carbolic acid, is a regular product of the decomposition of albumen. Indol is, therefore, constantly produced in the small intestine; some of it is evacuated with the fæces, while a portion is absorbed by the intestine, and arriving in the blood, it combines (like carbolic acid) with sulphuric acid and potassium, making the indoxylsulphate of potassium, or *indican*. The amount is increased by an exclusively flesh diet, but it does not disappear entirely during fasting. Possibly indican is formed in small quantity by normal tissue metamorphosis.

Excretion in Disease.—Indican is an ingredient of normal urine, derived by absorption from the intestine. In all pathological conditions in which the evacuation of the fæces is retarded, the quantity of indican in the urine

[1] A fact which possesses great pathological interest, though but little clinical importance, was established by Brieger. He found that while the amount of carbolic acid excreted in the urine is decreased in febrile conditions in general, such as pneumonia, acute rheumatism, and meningitis, yet in four infectious diseases an excessive amount of phenol is thus excreted; these diseases are diphtheria, scarlet fever, erysipelas, and pyæmia. In other infectious diseases, even though the temperature be equally high—small-pox, typhoid and intermittent fever—the amount of carbolic acid is less than in health. Brieger therefore infers that the four diseases named have a common etiological factor—the absorption of putrid products—and he terms them "putrefactive diseases." This observation accords perfectly with the recent investigations into the etiology of the septic diseases, which show that the introduction into the body of putrid products induce diphtheria, erysipelas, pyæmia, and septicæmia.

is increased. Jaffé observed an enormous amount in a fatal case of incarceration of the small intestine, and achieved the same result experimentally by ligating the intestine in dogs. In a case of incarcerated hernia, reduced twenty-four hours later, a similar increase of the indican in the urine was observed. In cases of diarrhœa, purulent peritonitis, and in habitual constipation, an excessive excretion has been noted; and it has long been known that in cholera the urine contains an excess of the same substance.

The excretion of indican, like that of carbolic acid, is increased in cases of pulmonary gangrene, cancer of the stomach, and similar conditions wherein putrid products gain access to the blood; yet Brieger found that indican and the acid are not always increased in the same degree.

Senator found that the urine of new-born children contains no indican —a fact quite in accordance with the observation that putrefaction does not occur in the fœtal intestine, and that no indol is discoverable in the meconium. He asserts that the granular atrophy of the kidneys is marked by an increased excretion of indican, while other forms of nephritis and the amyloid degeneration of the kidneys are not so accompanied.

In rare cases the indican becomes oxidized to indigo in the urinary passages, so that the urine is blue when evacuated. In other cases a spontaneous transformation into indigo occurs soon after emission.

Ford reports a case in which a stone consisting of blood-clots, phosphates, and indigo was found in the pelvis in a case of sarcoma of the kidney.

In addition to its occurrence in cases where decomposition products of albumen are present in the blood, indican has been observed in several pathological conditions where its presence cannot as yet be explained. It has been found in cases of cancer of various organs, especially of the liver; also in a case of melanotic cancer of the orbit. Rosenstein observed an increase in eleven out of twelve cases of Addison's disease. Robin has usually found an increase of indican in the urine of typhoid fever patients, and considers this a valuable item in differential diagnosis from conditions presenting similar symptoms, such as acute miliary tuberculosis. Urines containing much indican, when heated with nitric acid, exhibit a bluish, greenish, or reddish tinge—a fact which doubtless explains the existence of these tints in the urine of disease; for urines containing much indican are strongly acid, deposit uric acid, and decompose copper salts.

Urobilin.—This pigment (variously termed hydrobilirubin, urophain, and urohæmatin) is contained in normal urine in small quantity, and appears in larger amount during febrile conditions; it is also found in the bile. That which appears in the urine is obtained by absorption of the bile from the intestine; the greater part of the coloring matter remains in the alimentary canal, and colors the fæces.

Urobilin is derived indirectly from the coloring matter of the red corpuscles; indeed Hoppe-Seyler has obtained this pigment directly from hæmoglobin by treatment with hydrochloric acid and tin. It is therefore increased in all those pathological conditions which are accompanied by destruction of red corpuscles, such as fever. It has also been found in the urine in large quantity in cases of jaundice from intestinal catarrh.

Inorganic Constituents of the Urine.

All the soluble and some of the insoluble salts contained in the nourishment appear in the urine; the quantity varies naturally with that consumed. Yet the system evidently stores away a certain portion of the salts, since it is found that an animal fed upon a diet containing but little

of these salts excretes nevertheless a considerable quantity more than is contained in the food. That they constitute an essential part of the food is shown by the impairment of health and even fatal result which attend their absence from the diet. Ordinary food contains an abundance of such salts; it is only under special conditions (such as the transition from nursing to eating), that some of the salts—lime especially—may be present in insufficient quantity.

The Chlorides are for clinical purposes the most important of the inorganic constituents of the urine. They are derived chiefly from the food, and in health the quantity excreted in the urine varies with the amount consumed.

In febrile conditions the chlorides are retained in the tissues; the amount contained in the urine constitutes an index to the course of the disease, since this amount decreases and increases according as the pathological process is more or less aggravated.

The quantity of chlorides in the urine is increased by the absorption of dropsical fluids and inflammatory exudates. In diabetes insipidus there is, according to Vogel, an excessive excretion, while in diabetes mellitus the quantity is normal.

In cases of Bright's disease the estimation of the chlorides in the urine often furnishes information of much diagnostic value, as has been already explained.

The Phosphates excreted in the urine amount ordinarily to two or three grammes. Since the bones contain large quantities of phosphates, it would be expected that diseases involving disintegration of bone substance would be accompanied by an increased excretion of phosphates. Yet in most cases of rachitis and osteomalacia the amount of phosphates is found to be less than normal. In gout and chronic rheumatism the amount is also decreased.[1]

The term *phosphaturia* has been applied to an excessive excretion of the earthy phosphates, the amount being sometimes increased to three times the normal quantity. The amount of urea and the quantity of urine are also much increased, so that the condition has been termed "phosphatic diabetes." Notwithstanding the large amount of phosphates present, there may occur no precipitation of these salts, since the urine remains acid. At some period of the disease, however, the urine usually becomes alkaline, and then heavy white sediments of amorphous calcium phosphate are precipitated. This excessive elimination of the phosphates may be only temporary; or it may persist, in which case phthisis is sometimes developed. The cause of this peculiar excretion is unknown; it is observed almost exclusively in individuals suffering from general or sexual exhaustion, and sometimes appears suddenly after the patient has undergone a severe mental strain.

An excessive excretion of the alkaline phosphates of sodium and potassium is observed more frequently; it is usually accompanied with some

[1] There occurs a marked and constant diminution of the phosphates in all forms of parenchymatous nephritis—acute and chronic, with and without amyloid degeneration; the diminished excretion of phosphoric acid in these affections seems to run parallel with the decreased elimination of urea. Fleischer has shown that phosphoric acid administered to patients suffering from nephritis is not excreted in the urine, as it is by healthy individuals. It is probable, therefore, that in these renal affections there is more or less retention of the phosphates in the body. This fact is important in relation to the etiology of uræmia, since recent experiments make it probable that these retained phosphates play an important part in the production of uræmic poisoning.

polyuria. In many cases these phosphates are deposited as an amorphous sediment, the urine being persistently alkaline. This condition of the urine is commonly observed in connection with acute inflammations of the brain and spinal cord or their membranes, after acute mania and injuries to the head, and in many nervous individuals where none of these morbid conditions exist; it is a frequent symptom of neurasthenia and of sexual derangements. This persistent alkalinity of the urine and excessive deposit of the alkaline phosphates—often improperly called phosphaturia—is frequently accompanied with irritability of the bladder.

The Sulphates.—The decomposition of albumen furnishes a considerable quantity of sulphuric acid—from two to two and a half grammes of strong acid daily. The amount of the sulphates is therefore increased by animal diet. The sulphuric acid formed in the tissues is neutralized in carnivorous animals and in man by combination with ammonia. It is found that by administering free sulphuric acid to dogs a large increase in the ammonia salts of the urine is produced, the animal meanwhile suffering no impairment of health. Herbivorous animals, on the other hand, obtain but little ammonia from their non-nitrogenous food, and cannot supply it in sufficient quantity to neutralize free acid which may be administered to them; such acid is neutralized by the fixed alkalies abstracted from the tissues, and these suffer a corresponding impairment of function. A comparatively small amount of free sulphuric acid is therefore sufficient to destroy a herbivorous animal. Walter found that by neutralizing the acid with carbonate of sodium injections, the life of a rabbit could be saved even when the animal lay at the point of death from poisoning by acids. Herein is the explanation of the fact that herbivorous animals cannot exist upon a flesh diet unless it be accompanied with sufficient alkali to neutralize the sulphuric acid derived from such food.

Herbivorous animals ordinarily excrete an alkaline urine; when fasting, however, their urine becomes acid. They are, therefore, evidently dependent upon their food for the alkalies necessary to neutralize the acid formed by their own tissue metamorphosis.

The excretion of the sulphates has but little clinical significance; it is usually parallel with that of urea, since the sulphuric acid and urea are derived from a common source—albumen.

Ammonia.—The ammonia found in combination in the urine is derived in small part only from the food; the greater part proceeds from the decomposition of albumen. Much of it appears in the shape of urea; the amount which is excreted as a simple salt of ammonia is always small, the quantity varying with the amount of acid which is to be neutralized. If an excess of acid be contained in the blood, a large amount of ammonia is required (in man and the carnivora) to neutralize it; if but a small amount of acid be present, a limited quantity of ammonia may appear in the urine.

CHAPTER XI.

PATHOLOGY OF THE URINE (Continued).

Abnormal Ingredients of the Urine.

The following substances appear in the urine chiefly or exclusively in pathological conditions:

The albumens: serum albumen, serum globulin (paraglobulin), peptone, propeptone. Sugars: grape sugar, milk sugar, inosite. Biliary pigments, biliary acids, hæmoglobin, fat, sulphuretted hydrogen.

Albumen.—Since the urine is obtained by filtration from the blood, the most apparent and frequent sources for albumen in it are the albuminous constituents of the blood. The term albuminuria is, indeed, properly restricted to that admixture of albumen with the urine which occurs in the kidney—renal albuminuria. The admixture of pus, blood, or mucus brings albumen into the urine, a condition designated for convenience "false albuminuria."

Two albuminous constituents are constantly present in the blood—serum albumen and serum globulin. Yet these are not the only forms found in the blood, nor are they the only albuminous substances which filter into the urine. The two usual tests, heat and nitric acid, detect the presence of these two only; hence a negative result with these tests does not necessarily prove the absence of *all* forms of albumen from the urine. For there is contained in the blood-corpuscles an albuminous substance, *hæmoglobin*, which is under certain conditions liberated from them, dissolved in the serum, and then immediately filters into the urine. In addition to these regular constituents of the blood there are certain albuminous matters which under special circumstances are found in the circulating fluid, and hence in the urine also. Foremost among these is *peptone*, and a substance intermediate between albumen and peptone, called *propeptone*. Béchamp has further described as a constant ingredient in normal urine an albuminous substance called nephrozymase; this is, according to Leube, a mixture of two substances, an albumen and a ferment. In addition to these soluble forms of albumen there is occasionally found in the urine a solid albuminous substance, fibrin, as well as the coagulated masses of albumen known as "tube-casts."

Serum albumen is more commonly found in urine than any of the other varieties; indeed, we have come to regard albuminuria as signifying the presence of this substance in the urine. That the other varieties have been so seldom observed is doubtless due in large part to the fact that the tests generally employed for detecting albumen do not reveal them. Since the blood contains globulin, and since this substance is more diffusible than serum albumen, we would expect that it would also be present where the albumen is found in the urine; it is, in fact, actually demonstrated

that in most cases in which serum albumen can be detected, globulin is also present. Heat and nitric acid coagulate both of them, and do not therefore differentiate between them. Estelle has devised a method for separating globulin from serum albumen; the application of this method to the examination of albuminous urine shows that sometimes one, sometimes the other form is present, though usually both are found in the same specimen. Indeed in many instances the coagulum produced by heat and nitric acid is found to consist chiefly of globulin—an observation quite in accordance with the fact that globulin exists in the blood in larger quantity than serum albumen.

In certain pathological cases globulin alone is found in the urine; this is true, according to Senator, in cases of amyloid degeneration of the kidney, though this statement needs revision.[1]

Whether or not the distinction between these two forms of albumen in the urine may possess diagnostic value, has not as yet been determined. It has been shown that heat and nitric acid are by no means delicate tests for globulin, since they often fail to reveal minute quantities of it. Since, moreover, globulin is more diffusible than serum albumen, it seems quite probable that it may be often present undetected in urine which seems to be free from albumen.

Within recent years it has been demonstrated that *peptone* frequently appears in the urine during pathological conditions, and that it sometimes possesses diagnostic importance. Peptone escapes detection by the ordinary clinical tests, since it is not coagulated by heat or nitric acid. In some instances it is associated with serum albumen, while in others the latter substance is absent.

That there need be no association of the two is evident from a consideration of its source. Peptone is produced in the alimentary canal during digestion, but is transformed into albumen before it reaches the circulation. Hence the blood contains no peptone; even the portal blood exhibits only a trace of it for a short time after digestion. This fact explains its absence from the urine under ordinary conditions, since there is nothing to prevent its escape through the kidney when it is present in the blood. For it has been often demonstrated that peptone injected directly into the circulation or into the subcutaneous tissue, reappears in the urine at once. It may therefore be laid down as a general principle that peptone which gains access to the circulation by any other route than the alimentary canal, will appear in the urine.

Now there is at least one other source for peptone beside digestion. It has been ascertained that peptone is a constant product in the putrefaction of albuminous substances, and is moreover contained in every specimen of pus. Every collection of pus in the body is, therefore, a depot for the formation and absorption of peptone, which immediately appears in the urine. This fact has been already employed for recognizing deep-seated suppuration inaccessible to the trocar or hypodermic needle. Thus v. Jaksch detected the bursting of an ovarian cyst by the appearance in the urine of peptone derived from the pus of the consequent inflammation.

It is highly probable that suppuration is not the only pathological process whereby albuminous substances are transformed into peptone; for this substance is produced by the action of acids and alkalies upon albumen,

[1] A case of globulinuria during acute nephritis is reported in the New York Medical Record, No. 8, 1884.

and also by the influence of pancreatic juice. It seems plausible to suppose that various pathological states can so modify tissue metamorphosis as to change albumen into peptone in the body. While this assumption is not as yet demonstrated, yet it is a well-established fact that fever is usually accompanied by the appearance of peptone in the urine, without regard to the origin of the febrile condition. Furthermore, different agents which cause a pronounced alteration in tissue change are also productive of peptonuria. Thus peptone has been observed in the urine in cases of phosphorus poisoning, diphtheria, pneumonia, typhoid fever, and acute yellow atrophy; and it appears to be almost constantly present in cases of acute and chronic Bright's disease.

Lassar recently made an observation indicating the probable origin of peptone in the tissues under special circumstances. Having observed that serum albumen appeared in the urine in consequence of inunctions of petroleum for scabies, he experimented with rabbits to ascertain the effect of the same substance upon them. He found that inunctions of petroleum regularly induced in rabbits the appearance of peptone, followed after a short interval by albumen, in the urine.

Propeptone is one of the intermediate products in the transformation of albumen into peptone in the stomach. It is found in the blood during digestion and in pus; also in the medullary substance of bone in the healthy condition and in osteomalacia. Leube detected it in the albuminous urine of a patient suffering from urticaria, and Neale observed it in a case of hæmoglobinuria.

Senator maintains that the presence of propeptone in urine is much more frequent than has been supposed by writers and investigators. Within four years he detected this substance in seven different cases—tertiary syphilis, hæmiplegia, diphtheria, cancer of the œsophagus, pneumonia, and muscular atrophy respectively. The last case was remarkable; the patient had four years previously suffered from hemorrhagic nephritis, after recovery from which the urine for a long time contained albumen. Eighteen months later the albumen disappeared, but occasionally reappeared transiently; the subsequent discovery of propeptone was quite accidental. The patient had never had œdema, and exhibited no cardiac hypertrophy.

Since propeptone is not coagulated by heat, it is usually overlooked; indeed since propeptone is albumen at a certain stage of transformation into peptone, it would not be strange if it were found in urine in many of those conditions which induce peptonuria. Lassar, in his experiments with petroleum above referred to, found propeptone in the urine at a certain stage of the inunction.

CHAPTER XII.

ALBUMINURIA.

Physiological Albuminuria.

In order to determine the importance to be attached to the presence of serum albumen in the urine in pathological cases, it must be decided under what if any circumstances, independent of diseased conditions, albumen is present. It was formerly supposed that albuminuria was necessarily indicative of disease of the kidney; further investigation showed that it occurred in various pathological conditions other than renal disease. In course of time it was discovered that albumen is occasionally present in the urine of apparently healthy individuals; this occurrence, at first regarded as a physiological curiosity, was soon found to be by no means rare. It became further apparent that the urine of the same individual was at different times, even at different hours of the same day, sometimes free from and sometimes mixed with albumen.

Thus Leube examined the urine of 119 soldiers. He found that in the morning 5 individuals (4.2 per cent.) had albuminuria; at noon, after the military exercises of the morning, 19 (16 per cent.); in the evening, after resting for several hours, the number was decreased to the original 5 individuals. Munn found among 200 apparently healthy applicants for life insurance, 24 cases (12 per cent.) of albuminuria. Fürbringer found albumen in the urine of 7 out of 61 healthy children (11.5 per cent.); Kleudgen in 14 out of 32 healthy persons (44 per cent.).

Chateaubourg has recently reported numerous examinations of the urine from apparently healthy persons; he found albumen in the urine of 44 out of 98 soldiers, the specimen being passed three hours after dinner. Another test of the urine passed five hours after eating, revealed albuminuria in 76 out of 94 soldiers. In still another examination, he found albuminuria in 201 out of 231 cases, the specimen having been obtained after the performance of fatigue duty. These tests were made with especially delicate reagents.

Senator made an extensive series of observations upon himself and three assistants, all in the enjoyment of perfect health. Care was taken to obtain unmixed urine, by using for the examination only that last voided at each evacuation; in this way the urine was obtained free from the secretions of the urethra, which always contain albumen. In each of these healthy individuals, albuminuria was occasionally detected, usually during digestion.

In recent years this fact—that albumen is often present in the urine of perfectly healthy individuals, without exposure to unusual influences—has been established by numerous observers, among them Frerichs, Ultz-

mann, De Mussy, Vogel, Gull, Moxon, Lepine. In such cases the amount of albumen is rarely more and usually less than 0.1 per cent.

In a still larger number of cases, transient albuminuria is observed as a consequence of certain special influences. Thus it often occurs after cold baths, severe muscular effort, and the combination of these two factors, prolonged sea-bathing; after profuse perspiration, intense emotion. Fürbringer observed most carefully for a long period a healthy young physician who, under the influence of mental excitement, repeatedly evacuated urine of high specific gravity, containing as much as 0.6 per cent. of albumen; at such times he experienced dull pain in the region of the kidney. No casts nor other indications of renal disease were discovered; in the intervals between these periods the urine was quite free from albumen, and at the end of a year's observation the health was unimpaired.

The observations of Virchow, Ruge, and Martin show that in a large percentage of cases the urine of infants is albuminous during the first days of life.

Assuming that some of these apparently healthy individuals in whom temporary or persistent albuminuria has been observed are the subjects of unrecognized renal disease, it must be admitted that there remains a large contingent in whom the presence of albumen in the urine must be explained upon some other ground.

Senator argues that by the use of more delicate reagents a much larger percentage of cases of albuminuria in healthy persons would be revealed. But assuming that the results obtained by the ordinary tests represent a fair average, it follows that one out of every seven or eight individuals has at least now and then albumen in the urine. To explain this we must assume either that albumen is present in every urine, or that it may occur in every healthy person under special physiological circumstances. In the former case we must believe that the amount of albumen varies, being sometimes recognizable by our ordinary tests, and at other times too slight to be thus detected. Senator concludes that this is actually the case, namely, that the urine always contains albumen, though oftentimes in such small quantity as to escape detection by the reagents commonly employed. The epithelial cells covering the capillaries of the glomeruli are similar to the endothelial cells of serous membranes; hence it is reasonable to assume (in the absence of demonstrations to the contrary) that the fluid which passes from the blood through the cells, covering the glomeruli, has the same qualitative composition as that which escapes from the blood into serous cavities. Now it is well known that these serous fluids contain albumen; the cerebro-spinal fluid contains, for example, from one to three-tenths per cent. of albumen, as well as a due proportion of the salts of the blood. Analogy would therefore suggest that the liquid which escapes from the glomeruli into the renal tubules would also contain not only water and salts, but also albumen. The percentage of albumen would of course be less than that contained in the serous fluids, since the blood-pressure is greater in the glomeruli than in any other capillary system of the body; and it is well established that the greater the pressure during filtration, the larger is the amount of filtrate and the smaller the percentage of albumen. Hence the liquid filtered under great pressure through the glomeruli, while having the same qualitative composition as other transudations, would contain a smaller percentage of albumen.

The objections to the assumption that the urine, like other transudates, contains albumen normally, are chiefly three: first, that the ordinary clinical tests usually fail to reveal albumen in the urine of healthy persons;

second, that the observations of Posner, who coagulated the albumen in fresh kidneys by boiling, would seem to indicate that albumen is not found in the Malpighian capsules of the normal kidney ; third, that the glomeruli are the only capillaries in the body directly covered with epithelium ; hence the inference that these epithelial cells have some special function, possibly the power of preventing the escape of serum albumen from the capillaries.[1]

As to the first—the failure to detect albumen in normal urine by the ordinary tests—the answer is plain ; there is ample proof that these tests are incapable of revealing minute traces of albumen, which may therefore be present in many cases unsuspected. In fact, observations made with especially delicate methods, such as the potassio-mercuric iodide, reveal, as has been already stated, the frequent presence of albumen in healthy persons, in cases where heat and nitric acid show none.

Posner, by boiling pieces of fresh kidney, coagulated the albumen, and was thus enabled to demonstrate that in cases of albuminuria the albumen escapes into the tubules from the glomeruli—a fact which had been previously assumed, but not demonstrated. Inasmuch as Posner failed to find albumen in the capsules of normal kidneys treated in this way, he asserts that in normal kidneys no albumen escapes from the blood-vessels of the glomeruli. His conclusion is not, however, warranted by his observation ; for minute quantities of albumen can be present in the capsules without being discoverable by the microscope, even after coagulation by boiling. Albuminuria can be induced in rabbits very easily by rapid elevation of temperature, or by the injection of small quantities of phosphorus dissolved in olive oil. Such albuminuria is accompanied by granular tube-casts and by renal epithelium in the urine ; yet sections of the boiled kidney frequently show no albumen whatsoever in the capsules or tubules. A series of experiments conducted under Cohnheim's direction gave a similar absence of albumen in the capsules in cases of albuminuria induced by the injection of egg albumen into the circulation. The explanation is simply that the amount of albumen in these cases is so small that even when coagulated it is indistinguishable by the microscope.[2]

It is therefore demonstrated that normal urine may and frequently does contain serum albumen ; indeed, the recent extensive employment of delicate reagents (especially the potassio-mercuric iodide) furnish results which tend to support Senator's belief that albumen is just as normal a constituent of the urine as many of the ordinary ingredients. The researches of recent years have shown that several substances, formerly supposed to be occasional and accidental constituents of the urine, are con-

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[1] Heidenhain, Cohnheim.

[2] Heidenhain and Cohnheim have recently urged the hypothesis, already very popular in Germany, that the epithelial covering of the glomeruli possesses the power of preventing the escape of serum albumen from the blood, and that the appearance of albumen in the urine usually indicates an impairment of function of these cells. Whenever from any cause these cells are imperfectly nourished—as occurs in anæmia of the kidney, slowness of the circulation, ischæmia, etc.—they permit albumen to escape from the blood into the tubules. This theory lacks, as yet, experimental foundation ; but it is extremely convenient for explaining the albuminuria of many clinical cases. Some of its advocates have even assumed a congenital malformation of these epithelial cells for the explanation of cases of persistent albuminuria in apparently healthy individuals. This hypothesis fails to explain satisfactorily the well-known fact that other forms of albumen closely allied to that of the serum—egg albumen and peptone, for instance—meet no impediment in escaping from the glomeruli, but are at once excreted by normal kidneys whenever introduced into the blood.

stant and normal ingredients; this has been proven, for example, of indican, carbolic acid, hippuric and oxalic acid; and after much controversy it has been established that grape-sugar is frequently excreted in minute quantities by normal kidneys, and may even be present in appreciable amount in the urine of healthy individuals.

The time has certainly arrived when *the simple presence of albumen in the urine cannot be regarded as proof of any morbid condition of the kidneys;* the question is no longer, Does the urine contain albumen? but, *How much* albumen is present, *is it persistent,* and *are there any other indications, microscopical or clinical, of renal disease?*

Albuminuria from Pathological Conditions other than Renal Disease.

Many investigations, clinical and experimental, have been made to determine the various influences other than disease of the kidney which cause the escape of albumen into the urine. To enumerate these would exceed the scope of this chapter, which shall aim merely at summarizing the results already obtained. It must be admitted that the subject is but partially elucidated; the explanation of the albuminuria observed in many clinical cases is still uncertain and must so remain until the physiological relations of the kidney to the general bodily functions are more thoroughly ascertained. At present we are often unable to trace satisfactorily the effects upon the kidney of different disturbing factors involved in the same clinical or experimental condition.

It is, however, definitely established that albuminuria may result from any one of several influences; these will be briefly discussed.

1. *Increase of arterial pressure.* There are various methods for increasing general arterial pressure without inflicting injury upon the animal. First among these is *muscular activity.* It has been amply shown through observations with the kymograph that every muscular contraction tends to increase the general arterial pressure, and that violent muscular exercise may easily raise this pressure forty or fifty per cent. Now it is established by clinical observations that albuminuria occurs in healthy individuals with especial frequency after muscular effort. The observation of Leube already referred to, in which the percentage of cases of albuminuria in healthy persons rose from four to sixteen per cent. during muscular exertion, is an instance. It is also known that convulsions, tetanic and epileptic especially, are followed by albuminuria in persons whose urine is at other times free from albumen. Experimentally it has been observed that the struggles of animals while being bound upon the operating-table are followed by the excretion of albuminous urine, even though the urine evacuated just before this muscular action was quite free from albumen.

Another method for increasing arterial pressure experimentally without interfering directly with the activity of the kidneys, is *artificial elevation of temperature,* gradually induced. An increase of temperature of one or two degrees Centigrade causes an appreciable rise of arterial pressure and with it the appearance of albumen in the urine. Examination of the kidneys immediately afterward, by means of Posner's method of boiling, shows that the albumen has escaped as usual from the glomeruli.

The injection of *strychnine* or of potassium nitrate causes a marked rise of blood-pressure and the appearance of albumen in the urine. The latter seems to be the result of the increased pressure.

2. *Decrease of arterial pressure* is a frequent condition, which results

in general venous hyperæmia. It obtains sooner or later in most febrile conditions, in cases of collapse from pain or hemorrhage, and in valvular heart disease before compensatory hypertrophy; in all of these albuminuria is a frequent occurrence.

From an experimental investigation into the condition of the renal circulation during febrile conditions, Mendelson arrives at the following conclusions.[1]

1. That in dogs with fever the kidney undergoes a diminution in its bulk.

2. That this diminution is due to a contraction of the walls of the blood-vessels.

3. That it is constant and progressive, being proportionate to the intensity of the fever.

These observations afford a demonstration of the fact that the albuminuria as well as the oliguria usually attendant upon febrile conditions is attributable, in part at least, to the decrease of arterial pressure in the glomeruli.

It is probable that a very large number of clinical cases of albuminuria, aside from febrile conditions, are to be explained by the diminished arterial pressure in the kidney. For many subjects of anæmia and nervous exhaustion, especially during youth when the physical development is very rapid, exhibit slight albuminuria, which may be transient and temporary or may occur intermittently for years. Such patients often complain of headache and listlessness, are frequently nervous and sometimes suffer from dyspepsia and even diarrhœa. Owing to the prevalent negligence in examining urine, the albumen usually remains undiscovered; if detected, however, it usually arouses the gravest apprehensions. Such anxiety is needless (unless indeed there be evidences of renal disease); for the albuminuria seems to result merely from the diminished blood-pressure in the kidney as a part of the general anæmia; and it disappears so soon as the patient's general health is improved.

To the same cause must be referred the albuminuria often seen in wasting constitutional diseases, leukæmia, and conditions of general marasmus; also after profuse hemorrhage, in collapse and in the last days of life during exhausting diseases. The albuminuria which frequently appears during a febrile diarrhœa, may be in part due to the accompanying debility, though largely caused, doubtless, by the abstraction of water from the blood.

3. *Increase of venous pressure* occurs either from decrease of the arterial pressure or from impediment to the return of blood from the kidney. It has been found that simple pressure upon the renal vein of a dog produces albuminuria; the same result is caused by placing a ligature around the vein for ten or twelve minutes. If the kidneys be at once removed and boiled after Posner's method, coagulated albumen is found, not in the capsules, but in the tubules, especially those of the medullary portion. It appears, therefore, that the medullary part of the kidney suffers especially during venous hyperæmia. This is readily explained by the observations of Ludwig, who found that this temporary occlusion of the renal vein (the arterial pressure remaining unchanged) caused such distention of the veins in the medullary portion of the kidney as to compress and close completely the tubules surrounded by these veins. In short, venous hyperæmia causes—in the kidney, as elsewhere—œdema, *i.e.*, the transudation of

[1] Cartwright Prize Essay, American Journal of the Medical Sciences, October, 1883.

water, salts, and albumen from the smaller veins into the surrounding tissue. Since the tissue surrounding the veins in the kidney is composed of tubules, the transuded fluid must evidently escape into them, where it is mixed with the urine ; the latter, therefore, becomes albuminous.

Venous hyperæmia of the kidney occurs clinically in numerous cases. Valvular disease and fatty degeneration of the heart, impairment of the respiratory function, such as occurs in asthma, emphysema, and consumption—are familiar examples. In such cases the diagnosis of "Bright's disease"—based upon the presence of albumen and hyaline casts in the urine—is often erroneously made ; the writer has repeatedly seen such so-called Bright's disease—due to valvular disease of the heart—cured by digitalis.

The effect of venous hyperæmia from local mechanical obstruction was demonstrated in the familiar case reported by Bartels. This patient, suffering from visceral syphilis, had œdema of the lower extremities and enormous dilatation of the superficial veins of the abdomen. The autopsy showed thrombosis of the inferior vena cava above the entrance of the renal vein. In this case the patient evacuated more than the usual amount of urine, which was highly albuminous.

4. *Disease and injury of the nervous system* are directly responsible for albuminuria in many cases. Some of these are traceable *to injuries in or near the fourth ventricle.*

Claude Bernard discovered that puncture of the floor of the fourth ventricle was followed by albuminuria, and it has been since demonstrated that injury to certain portions of the cerebellum and of the crura cerebri induce the same result. Subsequent research has shown that the albuminuria in these cases of injury to the brain results from the consequent paralysis of the splanchnic nerves, whereby the general arterial pressure (including that in the renal artery) is much reduced. In such cases the albuminuria is to be referred, therefore, directly to the decreased arterial pressure, induced (through the agency of the splanchnic nerves) by the injury to the brain.

Clinically, such cases are not infrequent ; thus Frerichs reports fourteen cases of albuminuria without renal disease, in which post-mortem examination showed hemorrhage or inflammation involving the floor of the fourth ventricle, the cerebellum, or the crura cerebri. In all of these cases sugar was also found in the urine.

Various diseases affecting the nervous system are accompanied by albuminuria whose origin is obscure—tetanus, epilepsy, chorea, meningitis ; so are psychical disturbances, emotional excess, and nervous exhaustion. The observation of Fürstner, Weinberg, and Bummhave shown the especial frequency of albuminuria in cases of delirium tremens ; these observers noticed that the quantity of albumen rose and fell with the violence of the delirium, while the kidneys were apparently normal in several fatal cases.

Various transient nervous disturbances, such as intense emotion, shock, and pain, may also produce albuminuria ; paroxysms of pain, renal or biliary colic, and the "gastric crises" of tabes are frequently accompanied and followed for a few days by slight albuminuria.

5. *Changes in the Composition of the Blood.*—Egg albumen injected into the circulation of an animal, soon appears in the urine. In most cases the albuminuria thus induced ceases so soon as the quantity of albumen excreted by the kidneys equals that introduced into the circulation. In other instances the injection of egg albumen into the blood is followed by

a prolonged excretion of albumen by the kidneys; thus Stokvis observed in one case that four times as much albumen was excreted as had been injected. This excess of albumen must have been derived from the blood-serum; hence it is demonstrated that the simple presence of egg albumen in the blood can induce albuminuria.

It has also been shown that the injection of the serum albumen of dogs into the circulation of rabbits causes prolonged albuminuria in these animals. That the albumen excreted is derived chiefly from the rabbit's blood is shown by the fact that far more albumen is excreted than is injected, and furthermore that a destruction of the red blood-corpuscles occurs, evidenced by the appearance of hæmaglobin in the urine.

It is, therefore, well established that albuminuria can be induced by the presence in the blood of foreign substances—even though so nearly allied as the blood-serum of other animals—without any appreciable lesion of the kidney. It has been assumed that certain modifications of tissue metamorphosis in the body may result in the production of albuminous materials which may act like egg albumen or the serum albumen of other animals, and produce albuminuria. An analogy for this assumption is found in the fact that peptone, though normally absent from the blood, is produced in the tissues in certain pathological states—suppuration, acute yellow atrophy of the liver, and osteomalacia—and is then excreted in the urine.

It has also been assumed that disorders of digestion may result in the production of unusual forms of albumen in the stomach, which when taken into the circulation may cause the same effect as egg albumen—that is, albuminuria. This idea has been a favorite one among English authors since the time of Prout. Sir Andrew Clark is a believer in what is termed "hepatic albuminuria," *i.e.*, the escape of albumen in consequence of the presence in the blood of albuminoids intermediate between the peptones taken from the stomach and the fully metamorphosed serum albumen; since the liver is largely concerned in effecting these transformations, the presence of the intermediate albuminoids in the blood (and the consequent albuminuria) are attributed to disorders of this organ. It is certain that albuminuria is observed during many hepatic disorders; that the urine is at the same time loaded with urates and uric acid; and that a persistence of such hepatic derangement may be followed by Bright's disease.

While these are possible causes of albuminuria, it must be admitted that we have as yet no demonstration of these theories. All attempts to prove that albuminuria can be of hæmatogenous origin—*i.e.*, can result from a change in the albuminous constituents of the blood (except in those cases already mentioned, in which albumen is introduced into the body from without)—have failed.

So, too, it has been assumed that Bright's disease was consequent upon the presence in the blood of abnormal forms of albumen; but thus far no observer has been able to demonstrate the existence of such unusual forms of albumen in the blood of patients suffering from Bright's disease.

The only known *qualitative* change in the composition of the blood, therefore, sufficient to induce albuminuria (without causing disease of the kidney) is the presence of albuminous substances derived from foreign sources. There are, however, *quantitative* changes in the relative proportion of the different ingredients of the blood, which may doubtless play a considerable *rôle* in causing albuminuria. For it is a well-established principle that *the amount of albumen which filters through a membrane increases*, ceteris paribus, *as the albumen and the salts in the filtering fluid are*

increased. In those conditions, therefore, in which the blood contains an unusual amount of albumen or of salts or of both, or a deficiency of water, albumen is apt to appear in the urine.

Now, there are several physiological conditions in which the percentage of albumen and of salts in the blood is unusually high ; foremost among these is the process of *digestion.* For during this process the albuminous and saline constituents of the blood are augmented from the food and, as a result, the filtration of albumen through the membrane of the glomerulus is facilitated. Now, as a matter of fact, it has been often observed that, in those healthy persons who exhibit albuminuria, the albumen occurs with especial frequency and in greatest quantity during the process of digestion ; indeed, for these cases the term "digestion albuminuria" has been created. Furthermore, it has been ascertained that, in cases of pathological albuminuria, the amount of albumen excreted is greatest during the process of digestion. This digestion albuminuria is also most marked after the ingestion of highly albuminous food, such as meat and cheese.

The withdrawal of water from the blood effects of course the same result as an increase of the albumen and salts, namely, a relative augmentation of the latter. Hence an excessive excretion of water may be of itself sufficient to induce albuminuria. This has been amply demonstrated ; profuse perspiration, even when induced by pilocarpine, whereby the blood-pressure remains essentially unchanged, is followed frequently by albuminuria ; doubtless it is, in part at least, the loss of water from the blood which induces albuminuria so frequently in cases of afebrile diarrhœa.[1]

Albuminuria from Renal Disease.

Serum albumen can reach the tubules either from the capillary network surrounding them, or from the capillaries composing the glomerulus. In the former case there is disease of the epithelial cells lining the tubules, in the latter there is found degeneration of the capillary walls in the glomerulus. In most, though not all cases of renal disease both the tubules and the glomeruli exhibit pathological changes.

Albuminuria from Degeneration of the Tubal Epithelium.—The greater number of the true secretions of the body contain albumen furnished by the cast-off epithelial cells of the respective glands which are mingled with the secretions. A certain number of secreting glands—the liver, the sweat- and tear-glands—furnish a secretion which is, in the normal condition, free from albumen. The secreting cells of the kidney—those of the convoluted tubules—also furnish a product free from albumen. Now it has been ascertained that in abnormal conditions of the

[1] It is quite possible that variations in the alkalinity of the blood may be a factor in favoring the escape of albumen with the urine. For it is well known that the injection of alkaline liquids into the circulation induce augmented contractions of the heart and arteries ; while dilute acid solutions, on the other hand, diminish these contractions (Gaskell). Now the escape of albumen (as well as of sugar) is favored by dilatation of the vascular area supplied by the splanchnic nerves ; and it is certainly possible that a diminished alkalinity of the blood may favor such dilatation, and hence albuminuria. Such relative acidity of the blood occurs in gout and acute rheumatism, where transient albuminuria is a frequent phenomenon ; it doubtless exists also in disorders of the liver and pancreas whereby the alkaline secretions of these organs are repressed ; in these conditions, too, albuminuria is frequent. Possibly the value of alkaline mineral waters in diminishing the albuminuria of Bright's disease, is partly due to their influence in increasing the alkalinity of the blood.

liver, whereby the nutrition of the epithelial cells is impaired, the bile contains a certain amount of albumen; this has been observed by Frerichs in cases of hepatic congestion, by Thenard in cases of fatty liver, and by Lehmann in cases of granular and fatty liver. We might assume by analogy that fatty degeneration of the secreting cells of the kidney would also be accompanied by the escape of albumen into the secretion; but we are not compelled to rely upon analogy, since there is ample clinical and experimental proof that such is the case.

Albuminuria can be induced by the administration of certain substances, especially chromic acid, cantharides, phosphorus, and petroleum. Now it is established by the observations of Weigert and Lassar that these various poisons, administered in doses sufficient to cause pronounced albuminuria, produce merely a degeneration of the epithelial cells in the convoluted tubules, while the remaining elements of the kidney—the glomeruli, the interstitial tissue and the epithelium of the straight tubes—remain intact. The cells in the convoluted tubules present the peculiar condition called "coagulation necrosis;" that is, the outlines of the cells are lost, they coalesce into masses, lose their nuclei and their ability to absorb the ordinary staining agents. It is found, moreover, that the cells in this condition are unable to separate from the blood particles of the indigosulphate of sodium, which, as Heidenhain has shown, is always accomplished by these cells in their normal condition. Examination of these kidneys by the method of Posner (coagulation of albumen by boiling) shows that the convoluted tubules contain albumen, and that there is, moreover, a layer of this substance between the epithelial cells of these tubules and the basement membrane upon which they previously rested. The albumen is found only in those portions of the tubules where the epithelium is necrotic.

This constitutes, therefore, an admirable demonstration that serious interference with the nutrition of the epithelial cells in the convoluted tubules is sufficient to cause albuminuria. Clinically it is also established that albuminuria is a frequent accompaniment of phosphorus poisoning and of pernicious anæmia, in both of which conditions fatty degeneration of the epithelial cells in the tubules occurs. The excretion of highly acid urine, of urates and uric acid in excess, is sufficient to cause temporary albuminuria, probably from irritation of these cells.

In the so-called idiopathic cases of nephritis—Bright's disease proper—it is a familiar clinical experience that albuminuria is most constant and pronounced in that variety (chronic parenchymatous nephritis) in which degeneration of the epithelium is the most prominent morbid change in the kidney; in cirrhosis of the kidney, on the other hand, in which degeneration of the epithelium seems to be secondary to increase of connective tissue, albumen is found in the urine in comparatively small quantity, or may even be absent altogether.

Albuminuria from Degeneration of the Glomeruli.—It has become popular in recent years to ascribe to the epithelial cells covering the glomeruli the power to prevent the escape of albumen from the capillaries composing the tufts, and to assume that impairment of the nutrition of these cells is sufficient to permit albuminuria. However that may be, it is certainly established that a degeneration affecting the capillary walls of the glomerulus permits the escape of albumen into the tubules.

The most familiar example of this condition is the amyloid degeneration of the capillaries composing the glomeruli. While such amyloid change is, in the majority of cases, an accompaniment of nephritis, yet

cases of uncomplicated amyloid degeneration occur in which there is no nephritis, the cells of the tubules appear intact, while the glomeruli and their vasa afferentia alone exhibit the amyloid change. The pronounced albuminuria which almost invariably accompanies these cases of uncomplicated amyloid degeneration must be attributed to the abnormal permeability of the glomeruli.

Obstructive Albuminuria.—It is to be remembered that albuminuria may be produced by a purely mechanical impediment to the evacuation of urine, provided this causes an increased pressure of urine in the renal tubules. Partial occlusion of the pelvis or ureter, the pressure of an enlarged or displaced uterus, prostatic hypertrophy, urethral stricture, vesical spasm, tumor or calculus, even a tight phimosis (in infants)—in short, any condition capable of inducing hydronephrosis may also cause albuminuria; the latter symptom may long precede the development of a recognizable tumor of the kidney.

The pathology of albuminuria is by no means comprised in our present knowledge of the subject; many cases in which albumen appears in the urine remain still unexplained, while many others, in which albuminuria does not occur, are equally perplexing. Thus while albuminuria results from disorganization of the tubular epithelium and from amyloid degeneration of the glomeruli, yet cases are known in which, in spite of such disorganization and degeneration, no albumen has been discoverable in the urine.

CHAPTER XIII.

GLYCOSURIA.

Physiological Glycosuria.

Grape-sugar is constantly found in various tissues of the body, and is a normal ingredient of the blood. Since it is very diffusible, it would be expected that some of it would constantly filter through the glomeruli and appear in the urine. Mosler showed in 1853 that an exclusive diet of sugar and starch produced glycosuria in a healthy person; Eichhorst observed the same phenomenon after an exclusively milk diet, Helfreich after vegetable nourishment. In 1858 Brücke announced that normal urine usually contains a trace of sugar. Subsequent investigations have shown that this occurrence is by no means constant, though frequent. Glycosuria is, therefore, *per se*, no proof of an organic lesion, if it be but slight and transient; indeed, persistent glycosuria without any indication of a pathological condition is occasionally observed, especially in persons of nervous temperament, and in neurasthenic conditions.

The increased production of sugar during pregnancy and lactation is naturally accompanied by the circulation of an increased amount of this substance in the blood. In 1856 Blot discovered the frequent presence of sugar in the urine of pregnant and nursing women, a statement which has been often corroborated. It has also been ascertained that an arrest of the lacteal secretion, such as weaning, is followed by an increased excretion of sugar in the urine—a fact which has been explained by the recent investigations of Hofmeister and Kaltenbach, who found that the substance excreted under these conditions was not grape- but milk-sugar. This form of glycosuria has been accordingly termed "lactosuria."

As might be expected, the urine of infants nourished exclusively by mother's milk has been found to contain an appreciable quantity of milk-sugar (Eichhorst).

Glycosuria Independent of Diabetes.

Aside from the conditions mentioned in the previous paragraph—in which the increased quantity of sugar in the urine is the direct and natural result of an increased production or consumption of saccharine substances—there are numerous conditions in which glycosuria occurs without the other complex of symptoms designated "diabetes." Thus sugar has been observed in the urine—transiently and in comparatively small quantity—in cases of intermittent fever, tetanus, typhoid fever, gout, cardiac, and pulmonary inflammations; also after large doses of chloral, chloroform, ether, morphine, curara, and other poisons. In order to appreciate the

significance of such glycosuria, it is necessary to recall the formation and function of sugar in the animal economy.

Glycogen is produced from the various saccharine and starchy ingredients of the food by the action of the liver-cells. In the liver it undergoes a further transformation into grape-sugar, probably induced by a ferment which results from the breaking up of the red blood-corpuscles; at any rate, normal blood contains a ferment capable of transforming glycogen into grape-sugar.

Under ordinary circumstances this transformation occurs in such a limited degree that the sugar appears in the blood in only small quantity and in the urine merely as traces; under special circumstances, on the other hand, this production of grape-sugar is so rapid that the blood contains a comparatively large amount; hence the sugar filters through the glomeruli and appears in the urine in appreciable quantity.

After Bernard's discovery that lesion of the floor of the fourth ventricle causes glycosuria, it was ascertained that the liver is an active agent in this process; for if this organ be deprived of glycogen—by starving the animal or by the long-continued administration of arsenic (whereby the glycogenic function of the liver is arrested)—puncture of the floor of the fourth ventricle is not followed by glycosuria. Sugar introduced into the stomach of such animals appears at once in the urine (showing the abolition of the glycogenic function of the liver).

It was at first supposed, in explanation of the fact discovered by Bernard, that the brain exercised some direct and peculiar influence over the secretory activity of the liver-cells, but it was subsequently ascertained that lesions in other parts of the cerebro-spinal axis—the thalamus opticus and spinal cord—produced glycosuria; indeed, sugar appears in the urine without any other injury to the nervous system than simple section of the cervical and dorsal sympathetic. Since the only feature common to all these lesions is a dilatation of the abdominal blood-vessels and consequent increase in the quantity of blood circulating through the liver, it seems certain that the appearance of sugar in the urine after these various lesions results simply from the *increased circulation through the liver;* in consequence of this increased circulation, more sugar is carried to the liver than can be transformed into glycogen by the cells of this organ; hence some of the sugar passes through the liver unchanged into the general circulation and filters out of the glomeruli. The glycosuria which follows the administration of certain drugs, curara for example, is apparently caused in the same way, since these drugs are known to induce dilatation of the abdominal blood-vessels.

Numerous lesions of the nervous system have been found experimentally to induce glycosuria; among these are irritation of the first dorsal nerves, faradization of the central end of the divided vagus, as well as of the central end of the divided depressor nerve. Of far greater moment for clinical purposes is the fact that section or irritation of many spinal nerves has the same effect—glycosuria—as irritation of the abdominal sympathetic. Thus it has been amply demonstrated that section of the sciatic nerve causes glycosuria in animals—a fact of especial interest since transient glycosuria has been observed accompanying sciatica in the human subject (Eulenberg, Froning, Braun). Possibly the glycosuria which is observed in many cases of peripheral irritation, such as burns and inflammations of the skin, are to be explained in the same way.

In the majority of cases in which sugar appears in the urine in small quantity, its presence can be explained by the increased flow of blood to

the liver such as occurs after injury to the floor of the fourth ventricle. Such cases comprise the numerous instances of disease or injury to the brain and spinal cord; meningitis, cerebral and spinal, encephalitis, cerebral hemorrhage, tumors at the base of the brain, epilepsy, tetanus, rabies, tabes dorsalis, emotion, and psychical affections are examples; and it is probable that various drugs which are known to produce temporary glycosuria cause this effect in the same way—curara, morphine, nitrite of amyl, turpentine, ether, alcohol, chloroform, etc.

Yet there remain numerous cases in which the explanation of the accompanying glycosuria is not so apparent; such are gout, typhoid, recurrent and intermittent fevers, and diseases of the pancreas, in all of which sugar frequently appears in the urine temporarily. Sugar is also usually found in the urine in cases of chyluria of non-parasitic origin.

Glycosuria in Diabetes.

Until the pathology of diabetes shall be definitely ascertained, it must remain, as it is now, impossible to explain the presence of sugar in the urine as a symptom of this affection.

According to our present knowledge the complex of symptoms designated "diabetes" may be induced by any one of several causes; chief among these are, 1. Disease of the cerebro-spinal axis; 2. A perversion of cell-nutrition.

The autopsy usually shows some disease of the central nervous axis; these lesions vary extremely as to both nature and locality, tumors and inflammations of the brain and its membranes being the most frequent. In such cases there is usually observed polyuria and albuminuria intra-vitam and enlargement and congestion of the liver post-mortem. These clinical and anatomical features justify the assumption that the glycosuria is of analogous origin to that induced by Bernard's puncture of the fourth ventricle.

Yet cases of diabetes occur in which the autopsy fails to reveal such lesions in the nervous system as would explain the glycosuria. While these lesions are therefore by no means constant, there is another important and *constant* departure from the normal economy in the diabetic patient: the *increased and perverted tissue metamorphosis.* In every case of diabetes there occurs an increased excretion of urea, phosphoric acid, and carbonic acid, and a decreased consumption of oxygen. Gäthgens, Frerichs, and Külx have shown beyond doubt that the diabetic patient excretes far more urea than a healthy person consuming the same diet, and more than can be furnished by the food; there is, therefore, evidently an increased decomposition of albuminous matters in his body. Furthermore, it is ascertained that the urine of a diabetic patient contains more sugar than is furnished by his food; and since glycogen can be produced in the body from albumen, it seems probable that a part at least of the sugar excreted is derived from the decomposition of the albuminous constituents of the tissues.

Inosituria.—Inosite is isomeric with grape-sugar, and occurs in small quantities in many organs of the body—the muscles, liver, spleen, kidneys, brain, and lungs. It is not, however, found in normal urine except after the ingestion of large quantities of water, which apparently wash the sugar out of the tissues before it has undergone the usual decomposition.

Many attempts have been made to trace a relation between the excre-

tion of inosite and of grape-sugar in cases of diabetes. Bernard and Gallois found that the piqûre occasionally caused the appearance, not of grape-sugar, but of inosite in the urine; Schultzen observed inosituria in two patients suffering from tumors in the vicinity of the fourth ventricle; Ebstein found both grape-sugar and inosite in the urine of a patient suffering from disease of the medulla. On the other hand, Pribram observed a case of inflammation extending to the fourth ventricle in which neither grape-sugar nor inosite was discoverable in the urine, notwithstanding decided polyuria. Inosite has been repeatedly observed associated with grape-sugar in the urine of diabetics, and Vohl saw a remarkable case of diabetes in which the grape-sugar gradually disappeared and was replaced by inosite, 18 to 20 grammes of which were excreted per day. Gallois subsequently observed a similar case.

Yet there appears to be no definite etiological relation between glycosuria and inosituria. Külz found that after a six days' fast (whereby the glycogen of the liver was exhausted) the administration of inosite to rabbits did not cause glycosuria; he also found that the ingestion of inosite did not increase the quantity of sugar excreted by diabetic patients; indeed, in one case of diabetes he was enabled, by an exclusively nitrogenous diet, to cause the sugar to disappear from the urine completely, yet even then the administration of inosite was not followed by glycosuria.

For clinical purposes, therefore, the presence of inosite in the urine has no especial significance.

CHAPTER XIV.

EFFECT OF ACIDS AND PIGMENTS ON THE BLOOD.

Choluria.

The important constituents of the bile are the two acids, glycocholic and taurocholic, bilirubin and cholesterine. Both the acids and the biliary pigment are found occasionally in normal urine in minute quantity; their appearance in appreciable amount indicates an abnormal condition.[1]

Biliary pigment is formed from the hæmoglobin, the coloring matter of the blood-corpuscles. The transformation of hæmoglobin into bilirubin takes place normally in the liver, and abnormally in the circulating blood. Jaundice and the appearance of biliary pigment in the urine may, therefore, be due to, 1. Disorders of the liver, and 2. Disturbances in the circulating fluid; in the former case the jaundice is termed hepatogenous, in the latter hæmatogenous.

The bile which is discharged into the intestine is largely reabsorbed and returned by the portal vein to the liver, where it is again separated from the blood, only a trace passing into the general circulation to be excreted by the kidneys. Whenever, from any cause, an accumulation of bile occurs in the liver, its constituents are taken into the circulation and eliminated with the urine.

The most frequent cause of such accumulation is an impediment to the passage of bile through the biliary duct—occlusion by gall-stones, by swelling of the mucous membrane, by cancerous, syphilitic or cirrhotic new formations, by abdominal tumors, especially enlargements of the pancreas.

Transformation of hæmoglobin into bilirubin may occur in the blood without participation of the liver. It has been in recent years demonstrated that jaundice and the excretion of bilirubin in the urine can be readily induced by the injection of various agents into the blood by which blood-corpuscles are destroyed and their coloring matter converted into bilirubin. Chloroform, injected or inhaled, produces this effect—a result sometimes transiently observed after anæsthesia; injections of biliary salts, of hæmoglobin, and even of pure water can induce jaundice.

Such hæmatogenous jaundice is observed clinically in cases of septic infection—pyæmia and septicæmia—typhoid fever, malarial infection, as well as after poisoning by arsenic, chloroform, ether, etc. In such cases the biliary pigment appears in the urine before the skin is jaundiced; in-

[1] The appearance of the biliary acids in urine has no practical clinical value, because the process for their detection is too complicated for clinical use. It is only the biliary pigment which can be detected so readily as to come within the reach of clinical examination.

deed, the formation of bilirubin in the blood may be so slight that no jaundice occurs, although the pigment can be detected in the urine.

Choluria is usually accompanied with albuminuria.

Hæmoglobinuria.

Aside from the numerous cases in which blood is found mixed with the urine (in consequence of rupture of blood-vessels) there are frequent instances in which the urine exhibits the dark color characteristic of blood, and yet is found upon microscopic examination to contain no blood-corpuscles. The peculiar color in these cases is due to the hæmoglobin, which has been separated from the corpuscles in the blood and has escaped into the urine without any rupture of blood-vessels.

It has been established that hæmoglobin is one of those albuminous substances which leave the blood and escape through the kidney without restraint. It is excreted largely through the glomeruli by simple filtration, but appears to be in part also abstracted from the blood by the epithelial cells of the convoluted tubules. Under ordinary conditions hæmoglobin is of course retained in the blood-corpuscles, and thus prevented from passing out through the kidneys ; but so soon as it is separated from these corpuscles and dissolved in the serum, it escapes from the kidneys quite as readily as egg-albumen or peptone.

Hæmoglobinuria is therefore evidence that the blood-corpuscles have been exposed to some unusual condition whereby the hæmoglobin is separated from the rest of the corpuscle. Such separation occurs upon the introduction of certain substances into the blood. It has been experimentally ascertained that the injection of glycerine, mineral acids, chlorate of potassium, biliary salts, pyrogallic acid, naphthol, and even of pure water, is sufficient to cause such breaking up of the blood-corpuscles, and hence the appearance of hæmoglobin in the urine. The same effect often follows transfusion with the blood of a different animal, and extensive burns ; even a cold foot-bath is sometimes sufficient to induce hæmoglobinuria (Rosenbach).

Clinically hæmoglobinuria has been observed chiefly in conditions similar to those which are found to produce it experimentally ; in poisoning by chlorate of potassium, sulphuric, hydrochloric, carbolic, pyrogallic, and arsenious acids, naphthol, iodine, and nitro-benzole ; in burns and scalds, transfusion of lamb's blood, sunstroke, and fatty embolus. Extreme care should be taken in the administration of chlorate of potash, since remarkably small quantities of it have produced dangerous symptoms. Even after the ingestion of three drachms (in divided doses) of the chlorate, there have been seen dyspnœa, a small, weak pulse, cyanosis, icterus, hæmoglobinuria, and grave cerebral symptoms ; partial or complete suppression of the urine and death may follow within one or two days.

Many of the infectious diseases are occasionally accompanied by hæmoglobinuria—septic infection, intermittent and other malarial fevers, scarlatina, diphtheria, typhoid fever and hemorrhagic small-pox ; it has also been seen in scurvy and purpura, as well as after exposure to cold.

Idiopathic Hæmoglobinuria.—In the cases already mentioned the appearance of hæmoglobin in the urine is explained by the evident presence of a foreign agent in the blood, whereby the hæmoglobin is separated from the blood-corpuscles ; it occurs, however, where no such explanation is apparent, the patients apparently enjoying perfect health. In these

cases the hæmoglobin appears in the urine only at intervals, usually of several weeks or months, and is found for a few hours or days at a time.

The attack is preceded by signs of constitutional disturbance—prickling sensations in the skin, pains in the head, back, and limbs, a chilly sensation, or even a decided chill followed by fever and sweating; in the latter stage the urine exhibits the hæmoglobin; the skin often becomes somewhat jaundiced, apparently from the transformation of hæmoglobin into bilirubin; transient enlargement and sensitiveness of the liver and spleen are usual features of the attack.

The etiology of this paroxysmal, intermittent hæmoglobinuria is uncertain. The swelling and sensitiveness of the liver and spleen, together with the jaundice, indicate a derangement of one or both of these organs. Now since one of the numerous functions of the liver is doubtless the conversion of the hæmoglobin of the disintegrated blood-corpuscles into bilirubin, it has been assumed that a derangement of the liver might constitute the origin of the attack. Ponfick has shown that hæmoglobin may exist dissolved in the blood-serum without appearing in the urine; excessive disintegration of corpuscles causes first a swelling of the spleen and next enlargement of the liver; if both organs together are unable to remove the hæmoglobin, the excess filters out of the blood into the urine.

It is only when one-sixtieth of the entire amount of hæmoglobin in the blood is dissolved out of the corpuscles, that hæmoglobinuria appears. If the amount be even greater than can be disposed of by spleen, liver, and kidneys, jaundice occurs.

The attack often occurs after exposure to cold, and has been repeatedly induced artificially, in cases predisposed to the affection, by placing the hands or feet in cold water. The complaint is most frequent in winter and spring and rare in summer; and patients have themselves observed that the attack occurs only when they leave warm rooms.

In other instances hæmoglobinuria is induced by either physical exertion in general, or by some particular exercise; it has also been observed to follow regularly upon emotional excitement, such as accompanies venereal excesses.

A case reported by Fleischer is especially noteworthy. In this instance a robust soldier observed that the urine became bloody in appearance after he had been on the march for an hour or two; the intensity and duration of this color was proportional to the time spent in marching. It was found that the urine contained no blood-corpuscles, but simply hæmoglobin; and curiously enough no other form of exercise, no matter how violent, was followed by hæmoglobinuria, nor was it induced by cold foot-baths; yet it invariably followed after a march. In this case the patient had no fever nor other disturbance of the general health.

In some cases hæmoglobinuria is said to have occurred as a result of syphilis, and to have ceased under the employment of anti-syphilitic remedies; in other instances it has appeared as one of the incidents in an attack of rheumatism, and has disappeared when the rheumatic pains ceased.

That the hæmoglobin is actually dissolved in the blood-serum in these cases has been demonstrated in several instances: Küssner found that the blood removed from a patient during an attack of hæmoglobinuria by leeches furnished serum of a ruby red color; and Ehrlich observed a similar color in the serum of blood taken from the finger during an attack; he also noticed that the red blood-corpuscles were decolorized, many of them disorganized, and that those which retained their hæmoglobin showed a great diversity in size and shape.

In the majority of cases of hæmoglobinuria, serum albumen is found more or less constantly in the urine, accompanied naturally by hyaline casts. Masses of amorphous hæmoglobin in the form of casts, and (if jaundice exist) of biliary pigment, are also found. The epithelial cells of the kidney which may be present sometimes contain crystals of hæmatoidin.

The few cases in which post-mortem examination of the kidneys has been made show in these organs nothing abnormal except hyperæmia and the presence of pigment in the epithelial cells, and in the lumen of the tubules. In this situation the hæmoglobin appears as an amorphous, brown mass, or as yellowish brown balls. In cases of artificial hæmoglobinuria, these balls are often present in such quantity in the tubules as to present a radiating appearance.

Hæmoglobinuria seems to occur almost or quite exclusively in males.

The fresh urine contains, as a rule, only methæmoglobin, which is oxidized to oxyhæmoglobin only after standing for some time. In some cases the urine contains chiefly hæmatin, which gives an especially dark color; this has been observed in cases of diphtheria by Salkowski and Küster.

Chyluria.

A trace of fat is found in normal urine. In various abnormal conditions fat is excreted in considerable quantity. In one class of cases it is found thoroughly mixed with the urine, making an emulsion—chyluria; in another class the fat is not mixed with the urine, but floats as drops upon the surface—lipuria.

Chyluria occurs in two distinct classes of cases; in the one variety, which occurs exclusively in tropical climates, the patient's blood is found to contain a nematode worm in embryo form—the filaria sanguinis hominis; in the other class, comprising but few cases, various (mostly undiscovered) factors are involved.

As to the source of the fat in the urine, it is certain that it is derived from the food; for Brieger and others have shown that by withholding fatty articles from the diet, all fat disappears from the urine in cases of chyluria; and that it reappears again so soon as the food again comprises fatty articles.

As to the manner in which the fat escapes into the urine, no definite information has been obtained. It has been supposed that an obstruction to the thoracic duct might result in dilatation of the intestinal lymphatics and the establishment of abnormal communication with the urinary channels; this supposition is supported by the fact that chylous fluids occasionally collect in the peritoneal cavity, yet no demonstration to this effect has as yet been furnished. Experimentally chyluria has been induced by the injection of olive-oil into the blood-vessels. In one clinical case observed by Eggel the blood was found to contain an excessive quantity of fat, so that in this case at least the fat found in the urine may have escaped through the kidneys.

It is highly probable that the fat usually escapes through the kidneys, because the urine contains in all cases albumen, globulin, and often peptone; moreover, Brieger found that while the fat disappeared from the urine upon withdrawing fatty food, yet the albumen persisted. The fat also increased upon movement. In those cases of tropical chyluria, where the filaria is present in the patient's blood, the urine constantly contains blood and occasional worms. In these cases there is present also fibrino-

gen, whereby clots are produced in the urine, even before it leaves the bladder.[1]

The few post-mortem examinations which have been made upon cases of chyluria have usually failed to furnish any plausible explanation of this phenomenon. In a few instances there appears to have been a fistulous opening between the radicles of the thoracic duct and the urinary tract; in one case cancer of the stomach was observed, in another tuberculosis of the lungs. Even in those cases in which the filaria is present in the blood, post-mortem examination has failed to explain the appearance of fat in the urine.

Lipuria.

It is demonstrated that fat can be eliminated from the blood by perfectly healthy kidneys. Bernard found that fat appeared in the urine of a dog which had been fed for a week upon mutton fat exclusively. Wiener and Scriba further observed that injections of oil and fat into the blood were followed by its appearance in the urine, and that the fat escaped through the glomeruli.

The appearance of fat as drops upon the surface of the urine is termed lipuria; in such cases albumen is either absent or present only in small quantity, while in chyluria there is usually a large percentage of albumen as well as globulin and peptone.

Clinically lipuria is observed either with or without disease of the kidney. In the latter case it has been noticed after the ingestion of fats and oils; in diseases of the pancreas; in cases of poisoning by phosphorus, carbonic acid, and turpentine; in acute yellow atrophy of the liver, in obstruction of the bile-duct by gall-stones, and in yellow fever.

A most interesting observation is the occurrence of fat in the urine in cases of fatty embolus (Scriba) and in ordinary fractures (Riedel). It has also been seen in chronic diseases and tumors of bones, and in long-continued suppuration. In the latter case the fat seems to be derived from degeneration of the pus-cells; for Ebstein recently observed a case of lipuria following pyonephrosis.

The appearance of fat in the urine is said to be a frequent occurrence during pregnancy. In this condition as well as in diabetes, which is also accompanied by lipuria, the blood contains an unusual percentage of fat.

Chronic parenchymatous nephritis is often accompanied by extensive

[1] While attached to the medical staff of the London Hospital, I had the rare opportunity of carefully observing, for several months, a case of chyluria with filaria in the blood. (For a full report of the case see Path. Soc. Transactions, vol. xxxiii., p. 394.) In this case, as in all others on record, the worms were to be found only at night, at which time a drop of blood taken anywhere from the surface contained from fifty to one hundred of them. It is quite possible that the filaria has been repeatedly overlooked, because examinations of the blood were made only by day. The urine contained so much fibrin that it frequently coagulated in the bladder, causing retention and requiring the use of a catheter. The worms were to be found in the urinary sediment by day as well as by night, yet so entangled and hidden in masses of fibrin that they were often overlooked. In this case a reversal of the ordinary daily programme —the patient sleeping by day and remaining awake at night—caused a revolution in the habits of the worms, which were now found in the blood only during the day. This patient—a healthy young soldier, just arrived from India—remained quite well for several months, but ultimately developed abscesses in the joints, and finally died of pyæmia, about eleven months after the chyluria was first noticed. At the post-mortem examination the adult worm was not discovered.

fatty degeneration of the kidney; in a few instances of this affection, fat has been observed in the urine; lipuria has also been seen in cases of cystitis, presumably from fatty degeneration of pus.

Fibrinuria.

In rare cases the urine coagulates some time after emission into a jelly-like mass. The coagulation is not dependent upon admixture of blood, since blood-corpuscles are few in number or may be absent entirely. This condition is said to be endemic in Brazil, Madagascar, and the Isle of France; as to its etiology nothing is known, though the occurrence of fibrinuria with the filaria sanguinis in tropical regions suggests the possibility that such endemic fibrinuria may be due to this parasite.

A similar condition of the urine has been observed in cases of papilloma of the bladder, in a few instances of Bright's disease, and after the use of cantharides.

Hydrothionuria.

Sulphuretted hydrogen is evolved during the decomposition of urine containing cystine; but it has also been observed in fresh urine, chiefly in cases of cystitis, where it is produced by decomposition of pus. In a few cases of abscesses in the vicinity of the intestine, it has also been found. Emminghaus has described two cases of hydrothionuria after suppurative peritonitis following perforation, and Betz observed it in a case of prostatic hypertrophy with dilatation of the rectum. In these and other cases the sulphuretted hydrogen appears to have been absorbed from the intestine or adjacent abscesses. In one case Dittel observed an escape of gas with the urine, the autopsy showing a vesico-intestinal fistula.

CHAPTER XV.

DAILY AMOUNT OF URINE.

While the average daily quantity excreted by an adult is usually between thirty and sixty ounces (1,000 and 2,000 c.c.), it may be diminished to 500 or increased to 3,000 c.c. for a day or two during perfect health; for such variations may be occasioned by temporary changes in the quantity of liquid consumed as well as in the activity of other excretory organs, especially the skin and the bowels. There are also other influences which induce increased or diminished excretion of urine; the quantity is increased by

1. *An abundant supply of animal food.* Ranke observed in one case the daily excretion of over 3,000 c.c., while during a period of starvation the amount passed by the same patient was reduced to 750 c.c. Seegen saw the quantity decreased even to 125 c.c. per day. This increased excretion is due in large part to the excessive production of urea upon an animal diet, the diuretic effect of which is well known.

2. *Psychical influences.* Beneke observed during conditions of physiological exaltation an increase from 60 to 200 c.c. per hour, and during physical and mental depression, a decrease from 60 to 15 c.c. per hour.

3. *Increase of arterial pressure.* This results in increased rapidity of filtration through the glomeruli, and hence polyuria; digitalis increases the renal excretion in this way.

A decrease in the force and rapidity with which the blood circulates through the glomeruli causes, on the other hand, a diminished excretion of urine.

4. *The presence in the blood of some substance which excites the secreting cells of the kidney to increased activity.* Jaborandi, saltpetre, and urea increase the urinary excretion. The diuretic effect of urea is often observed in the polyuria which occurs at the beginning of convalescence from febrile affections, constituting an important feature in the so-called "crisis" of the case. This critical diuresis appears to be due to the effect of the accumulated urea upon the kidney cells.

The quantity of urine excreted is influenced in disease, and doubtless in health, by the nervous system. Bernard observed that injury to a certain locality in the floor of the fourth ventricle causes marked increase in the quantity of urine excreted; the same effect follows section of the splanchnic nerves, and it has been demonstrated that the diuresis which follows Bernard's piqûre is due to the consequent paralysis of the renal artery, supplied by the splanchnic nerves.

Section of the cervical cord or irritation of the dorsal cord induces an arrest of the urinary excretion by irritating the splanchnic nerves, whereby contraction of the renal arteries is produced; indeed, direct irritation of

these nerves has also a marked effect in decreasing or even arresting the urinary excretion.

Many clinical cases of polyuria are caused by disease or injury in and around the fourth ventricle. In cases in which the symptoms have indicated and the autopsy has proven disease, hemorrhages and tumors of the central nervous system, the medulla, the cerebellum, and the spinal cord, polyuria has been a constant symptom. Injuries to the brain and to the skull have been accompanied by this same symptom.

In another class of cases the influence of the nervous system is equally apparent though less intelligible. Examples are seen in the excessive excretion of urine after a hysterical attack; in some cases of hysteria polyuria is not a transient but a persistent symptom. In epilepsy, too, a persistent increase in the excretion of urine has been observed.

It has been already stated that the quantity of urine excreted is diminished by irritation of the splanchnic nerves whereby contraction of the renal arteries is induced. It would seem that such irritation of these nerves occurs in cases of lead poisoning. Riegel observed that in lead colic the amount of urine decreased as the pain and arterial tension increased; this relation was especially apparent where the attacks of colic recurred at intervals of several days.

The quantity of urine is mechanically decreased by obstruction in the urinary channel—a result which is to be attributed to the increase of pressure on the outer side of the glomeruli, and consequent decrease in the rapidity of filtration. Renal calculi, tumors compressing the ureters, the swelling of the bladder mucous membrane in cystitis, paresis of the bladder, hypertrophy of the prostate, stricture, may all decrease the quantity of urine excreted.

Reaction of the Urine.

The reaction of the urine varies considerably in health even in the same person, and at different hours in the same day. It is dependent upon the degree of alkalinity of the blood, and this in turn largely upon the diet of the animal; thus carnivorous animals have a markedly acid urine, while the herbivora excrete a constantly alkaline urine. In man the urine is generally slightly acid; the degree of acidity is much increased by an excess of animal food, and diminished by vegetable food.

The alkalinity induced by vegetable food seems to be due to the vegetable acids therein contained—citric, tartaric, acetic, etc.; for these are oxidized into carbonic acid in the organism, producing alkaline carbonates. It is found also clinically that the administration of these acids or salts containing them—citrate, tartrate, or acetate of potassium, for instance—induces alkalinity of the urine.

The alkalinity of the blood (and therefore of the urine) is increased not only by the addition of alkalies, as occurs upon vegetable diet, but also by the abstraction of acids, which takes place during digestion. For the separation of hydrochloric acid by the gastric glands increases the alkalinity of the blood. It has been found both experimentally and clinically that there is a constant and direct relation between the secretion and deposition of the gastric juice on the one hand, and the acidity of the urine on the other. It has been shown by experiment that when the gastric juice of a dog is permitted to escape through a fistula, the urine (normally acid) is alkaline and so remains until the escape of gastric juice is pre-

vented. The same result was obtained by Quincke, by removing the gastric juice through a stomach-pump. Clinically it has been often observed that patients suffering from persistent vomiting excrete alkaline urine.

The explanation of this alkalinity, observed in experiment as well as clinically, is evidently that the removal of the gastric juice from the body prevents its resorption into the blood and thus increases the alkalinity of this fluid and therefore of the urine derived from it. The alkalinity of the urine (absolute or relative) which is physiologically observed soon after the ingestion of food is therefore most plausibly explained by the formation of hydrochloric acid in the stomach; for the formation of this acid seems to be accomplished by the separation of hydrogen from the acid phosphate of sodium, which becomes the neutral phosphate; and since the acidity of the urine depends largely upon the presence of this acid phosphate, the disappearance of this salt results in diminished acidity of the urine.

Dr. Ralfe suggests that there may be another factor in the production of this alkalinity during digestion, namely, the increased exhalation of carbonic acid by the lungs. Edward Smith has shown that during digestion this exhalation is increased, while it is diminished by fasting and by sleep. The acidity of the urine is inversely proportional to this exhalation, being least during digestion and greatest during sleep.

The reaction of the urine is affected in many derangements of the digestive and of the respiratory organs. Any interference with the elimination of carbonic acid, or excessive production of the same, may be followed by an excessive excretion of alkaline carbonates, and consequent alkalinity of the urine; such is often the case during convalescence from acute diseases.

The failure to secrete normal gastric juice, as in certain forms of dyspepsia, or its removal from the stomach by persistent vomiting, may cause alkalinity of the urine. Any condition such as duodenal catarrh, which prevents the discharge of bile into the intestine, causes an accumulation in the blood of alkaline carbonates which would otherwise escape with the bile and, in part at least, be discharged with the fæces; hence such condition may thus indirectly produce alkalinity of the urine. Probably a suppression or retention of the pancreatic secretion occasions the same result in a similar way. Fermentation in the small intestine causes the production of certain fatty acids which are oxidized in the blood into carbonic acid, resulting in the excretion of alkaline carbonates in excess and consequent alkalescence of the urine (Ralfe). Such fermentation produces the symptoms of dyspepsia with constipation and flatulence, usually associated with alkaline urine. If these acids (lactic, butyric, etc.) are produced in the small intestine in excess, the oxidation is incomplete, producing oxalic acid, whereby the urine is rendered acid and the condition termed "oxaluria" may be developed—dyspepsia, flatulence, and a copious precipitate of calcium oxalate crystals.

CHAPTER XVI.

URINARY SEDIMENTS.

From Acid Urine.	From Alkaline Urine.

A. UNORGANIZED.

1. *Amorphous.*

Urates of sodium and potassium. Phosphate and carbonate of calcium.

2. *Crystalline.*

1. Uric acid.
2. Oxalate of calcium.
3. Cystin.
4. Tyrosin.

1. Triple phosphate (ammonio-magnesium phosphate).
2. Urate of ammonium.
3. Phosphate of magnesium.
4. Phosphate of calcium.

B. ORGANIZED.

1. Epithelial cells.
2. Blood-corpuscles.
3. Pus-corpuscles.
4. Tube-casts.
5. Spermatozoa.
6. Fragments of morbid growths.
7. Entozoa.
8. Fungi.
9. Bacteria.

1. Uric Acids and Urates.—The neutral urates of sodium and potassium are contained in every normal urine in perfect solution; through the action of the acid phosphate of sodium contained in the urine, these neutral urates are, in the course of a few hours, decomposed into the acid urates and free uric acid; since these substances are far less soluble than the neutral urates excreted by the kidneys, a precipitate occurs.

Although such precipitation of the acid urates of sodium and potassium as well as of uric acid usually occurs only some hours after the urine has been voided, yet in certain states, normal as well as pathological, it occurs before the urine has left the body; it is favored by:

(1.) *Excessive acidity of the urine.* This occurs especially when the diet contains an undue proportion of nitrogenous (animal) food, since the decomposition of albumen in the body is accompanied by the formation of free acids. In cases of gout and of the so-called "uric acid diathesis," the urine is usually decidedly acid, and furnishes an abundant sediment of urates.

That the precipitation of the urates may be quite independent of the actual production in the body, and entirely dependent upon the reaction of the urine, is shown in examples mentioned by Bartels:

In a case of capillary bronchitis the patient excreted in twenty-four hours 920 c.c. of urine, containing 4.5 per cent. of urea and 0.123 per cent. of uric acid; the reaction was alkaline and the urine contained no sediment.

In a case of typhoid fever there was excreted in twenty-four hours, 920 c.c. of urine, containing 4.4 per cent. of urea and 0.098 per cent. of uric acid; the reaction was acid, and as a consequence a heavy sediment was precipitated.

(2.) *Scantiness of the urine.* This occurs especially when the watery elements of the blood are largely excreted by the skin, the bowels, and the lungs, as in cases of profuse perspiration, diarrhœa, etc.; also in febrile conditions.

(3.) *Excessive excretion of uric acid,* such as happens at the so-called "crisis" of many febrile affections.

(4.) *Cooling of the urine,* since the urates and uric acid are less soluble in cold than in warm water.

Clinically the occurrence of a uric acid deposit is an important item in diagnosis only when in freshly voided urine and persistent. In such cases it will be found that the urine is highly acid, and that the crystals of uric acid are rough, pointed, and often arranged in rosettes. The detection of such forms suggests the suspicion that the deposit of uric acid and urates is occurring in the urinary passages, and should therefore stimulate further examination of the urine as well as of the patient. In such cases albumen, blood, pus, and epithelial cells from the kidney and from the pelvis confirm the suspicion that uric acid concretions may be forming in some portion of the urinary tract; in other cases the chief symptom noticed is a scalding upon urination suggestive of incipient gonorrhœa. Even though none of these conditions can be detected, a patient who habitually passes very acid urine, in which rough and pointed crystals of uric acid are soon precipitated, perhaps even while the urine is still warm, should receive alkalies in order to avert pyelitis and nephritis. After the administration of alkaline carbonates or vegetable acids, it will be found that the uric acid is precipitated not as rough, pointed crystals, but in the usual whetstone shapes.

In certain conditions, especially gout and the so-called uric acid diathesis, the acid and its compounds accumulate in the blood and may even form concretions in the skin and around the joints. It has been customary to regard these phenomena as indications of an over-production of uric acid in the tissues; recent researches make it, however, probable that this accumulation in the tissues results not from excessive production, but from deficient excretion; that this imperfect excretion is due to diminished alkalinity of the blood, which in its turn is the result of addiction to nitrogenous food, whereby an undue amount of acid is produced.

It was formerly supposed that the accumulation of uric acid in the tissues was favored by insufficient oxygenation of the blood; this idea

rested chiefly upon the hypothesis that urea was produced by the oxidation of uric acid, and that a deficiency of oxygen would therefore prevent the usual oxidation of the acid. Subsequent researches have, however, shown, first that urea is produced chiefly in other ways than by the oxidation of uric acid; and second that deficient oxygenation of the blood does not, as a matter of fact, clinically or experimentally, favor the increased production and excretion of uric acid.

2. Oxalate of Calcium.—This is usually found in acid urine in company, therefore, with uric acid and the urates; it is not, however, dissolved by a slightly alkaline reaction of the urine. The octahedral crystals of the oxalate usually appear in greater quantity after the urine has stood for several hours; indeed, in some cases none of these crystals can be detected in the freshly voided urine, while they are found in abundance after the lapse of some hours.

The reason for this subsequent appearance of the oxalate of calcium crystals in the urine is the disappearance of the acid phosphate of sodium. Neubauer showed that the oxalate is held in solution by the acid phosphate; since the latter gradually combines with the urates, the oxalate of calcium is gradually thrown out of solution and appears in the sediment.

The important inference from this fact is that the quantity of oxalate of calcium found in the sediment is determined not by the quantity excreted, but by the reaction of the urine. Even though the sediment contains no crystals of the oxalate, the urine may hold an excessive quantity of this salt in solution; and conversely the appearance of numerous crystals of the oxalate in the sediment does not prove that an abnormally large amount of the salt is excreted by the kidneys. Fürbringer's investigations show most clearly that there is no definite ratio between the amount of the oxalate actually contained in the urine on the one hand and the number of crystals found in the sediment on the other; thus he found in some cases with a total excretion of ten milligrammes a greater number of oxalate crystals in the sediment than occurred in other cases with an excretion of nearly twenty milligrammes.

Oxaluria.—Many of the English authors have recognized, under this name, a distinct pathological condition, indicated by mental depression, dyspepsia, pain in the epigastrium and in the loins, emaciation and diuresis; since, in such cases, numerous oxalate of calcium crystals have been found in the sediment of the urine, it has been supposed that the symptoms originated in an increased production of oxalic acid in the body. Since it is now known, as has been stated, that there is no constant relation between the amount of oxalic acid excreted, and the number of oxalate crystals in the sediment, it is evident that there is no ground for ascribing the symptoms enumerated to the presence of oxalic acid in the blood.

Clinically the appearance of oxalic acid in the urine is not associated especially with any pathological condition; an increase has been frequently observed in cases of diabetes, and Cantani has recently recorded a case in which sugar and oxalic acid were alternately excreted in large quantity. Fürbringer detected oxalic acid in the sputum of a diabetic patient. Calcium oxalate crystals are sometimes found in excess in cases of fermentation in the small intestine, whereby fatty acids are produced; if these are only partially oxidized in the blood, oxalic acid is formed.

The quantity of the acid excreted is of course increased by the ingestion of vegetables containing it—beets, turnips, spinach, cabbage, apples, oranges, tomatoes, grapes, etc., rhubarb, squills, valerian.

3. Cystin.—This is a rare sediment, usually found in individuals who suffer from cystin stones; yet it may occur dissolved in the urine without the formation of vesical calculi and even without the precipitation of crystals in the sediment.

The fact that cystin contains sulphur and nitrogen indicates its origin in the albuminous constituents of the body. Many efforts have been made to ascertain whether the excretion of cystin is accompanied by a diminution in the other urinary ingredients containing nitrogen and sulphur; it has been determined that there is usually, in such cases, a decrease in the excretion of uric acid and of the sulphates; further than this no constant deviation has been observed.

In one case Marowsky observed cystinuria associated with a diminished activity of the liver (acholia); Ebstein and Salisbury have noticed cystinuria during acute rheumatism, the cystin disappearing after convalescence from the disease. Ebstein's case was especially noteworthy from the fact that albumen was associated with cystin, both disappearing from the urine at the same time. In another case Ebstein observed cystinuria in a syphilitic patient; after the employment of mercurials the cystin disappeared.

Only one observation as yet indicates a direct influence of the diet upon the production of cystin: Ebstein observed that the quantity excreted was tripled after the ingestion of peas.

Clinically, therefore, the occurrence of cystin in the urine—cystinuria—has as yet no especial significance. As yet only sixty-one cases have been observed, of which forty-five (seventy-five per cent.) occurred in males. Cystinuria has been noticed most frequently in youth, occasionally during middle age, but with extreme rarity after the fiftieth year. It has been repeatedly observed in different members of the same family, though whether from a common predisposition or as the result of common surroundings is not known. Thus Toel saw cystinuria in three members of the same family, mother and daughters, and Ebstein detected it in two brothers. Most of these individuals enjoy apparently perfect health.

4. Leucin and Tyrosin.—Leucin is found normally in small quantity in the spleen, the pancreas, the liver, and lymph glands; also in the seeds of certain plants. It is produced in larger quantity during the putrefaction of the glands above named, as well as by the action of pancreatic juice upon albuminous substances; it is therefore evidently constantly produced in the alimentary canal. Since, moreover, it is formed by the action of acids and alkalies upon albumen it seems probable that it may be formed in the body as a part of normal tissue metamorphosis. At any rate it has been discovered that during the germination of plants leucin and tyrosin are produced out of albuminous substances.

Though a certain amount of leucin must therefore be present in the body, yet it appears to undergo further change before elimination, since it is never found in urine during health. Even the administration of considerable quantities of leucin by the mouth does not cause its appearance in the urine; there does occur, however, a decided increase in the amount of urea excreted, whence it is inferred that some of the leucin at least is transformed into urea in the body. In plants it is known that leucin combines with hydrocarbons, producing albumen; since the increased excretion of urea which follows the administration of leucin by the mouth does not account for all of this substance administered, it is quite possible that a similar combination occurs in the animal.

As yet leucin is known to occur in the urine only in two pathological

conditions—acute yellow atrophy of the liver and acute phosphorus-poisoning; its reported occurrence in cases of small-pox, typhoid fever, and glanders is rare or altogether doubtful. Since in the two diseases named the liver is disorganized, and little or no urea excreted, it seems plausible to infer that the metamorphosis of leucin into urea and albumen occurs normally in this organ.

In acute yellow atrophy of the liver leucin and tyrosin appear in the urine in large quantity; in acute phosphorus-poisoning, on the other hand, in small quantity. This fact has been employed for differential diagnosis between the two affections (Schultzen and Riess). It must be remembered, however, that cases of undoubted acute liver atrophy have been observed in which neither leucin nor tyrosin could be found in the urine.

Tyrosin seems to be formed in the human subject under precisely the same conditions which give rise to the production of leucin; at any rate, they appear together in the urine.

The normal acidity of the urine is sometimes replaced by a neutral or acid reaction. This occurs chiefly after, 1. Digestion; 2. The ingestion of alkalies or of vegetable acids (which are transformed in the blood into carbonates); 3. Ammoniacal fermentation of urea; 4. Admixture of blood or pus. Alkalinity of the urine has been observed, though not constantly, in various conditions—anæmia, disease of the central nervous system, after muscular exercise and warm baths.

The sediments peculiar to alkaline urine are the salts of calcium, magnesium, and ammonium, which are comparatively insoluble in alkaline liquids. Litmus paper reveals not only the alkaline reaction, but also distinguishes between the salts of calcium and magnesium on the one hand and of ammonium on the other; for red litmus paper, turned blue by ammoniacal urine, soon regains its red color upon exposure to the air in consequence of the volatility of the ammonia; while if the alkalinity of the urine be due to other bases than ammonium, the litmus retains its blue color.

These salts appear to be retained in solution largely by the carbonic acid contained in the urine; upon the application of heat, whereby this acid is expelled, the sediment is much increased. Another phenomenon manifested by alkaline urine appears to be also due to the escape of carbonic acid, namely, the production of a variegated scum upon the surface. This scum is found to consist chiefly of phosphate of calcium, precipitated on the surface by the escape of carbonic acid.

The appearance of the phosphates of magnesium and calcium in the sediment has no especial significance in alkaline urine; their persistent occurrence in neutral or slightly acid urine is sometimes observed in various neuroses.

The appearance in fresh urine of the triple phosphate (ammonio-magnesium phosphate) and the urate of ammonium, on the other hand, has great clinical significance, since these two salts occur almost exclusively in cases where urea is transformed into carbonate of ammonium in the bladder, *i.e.*, cases of cystitis. Normal urine contains comparatively little ammonium, and it is only when an excess of this base is produced by the fermentation of urea that the formation of its salts in considerable quantity is possible. It must, however, be remembered that the triple phosphate is not found exclusively in cases of cystitis; occasional crystals are observed in normal alkaline urine.

Organized Sediments.

1. Epithelial Cells.—The epithelium lining the urinary and genital tract presents chiefly three varieties of cells: 1. Flat cells; 2. Columnar and caudate cells; 3. Round cells. Columnar and caudate cells are found in various sections of the urinary mucous membrane—the urethra, the bladder, the ureters, and the pelvis of the kidney; hence their appearance in the urine cannot be traced to any particular portion of the tract unless attendant circumstances furnish a clew. In most cases fortunately such circumstances are present, either as characteristic features of the urine or as symptoms presented by the patient. It is rarely difficult to decide upon the origin of these columnar cells, except when the diagnosis rests between prostatitis and pyelitis, since in each condition these cells may appear accompanied by threads composed of pus-corpuscles. In pyelitis, the urine is found to contain albumen, more than the pus present should furnish, while in prostatitis albuminuria is not a symptom; in pyelitis, furthermore, the urine is usually quite acid and often contains pointed rough crystals of uric acid.

The flat cells are derived either from the bladder or from the vagina. These cells from the bladder occur singly or in a single layer, while those from the vagina are larger, usually grouped, and in several layers.

The round cells are derived either from the tubules of the kidney or from the deeper layers of the pelvis. Their original form in the tubules is not circular but polygonal; sometimes such cells are found in the urine, but in most cases the angles have been obliterated by the absorption of water. These round cells are often confused with the young, half developed flat cells from the bladder; in fact, it is practically impossible even for an expert to distinguish individual cells from these two sources; it is only when the kidney cells occur in groups, thus presenting their polygonal form, that the recognition can be made with perfect confidence.

Variations from the typical form of the epithelial cells are frequently seen; this is especially true of the columnar cells, which often exhibit long caudate extremities on one or both sides. Such cells are often regarded as indications of malignant new formation—"cancer cells." These unipolar and bipolar caudate cells are, however, normally produced in the pelvis of the kidney, in the bladder and urethra; occurring individually they do not alone indicate a morbid growth.

2. Blood.—The admixture of blood with the urine is a frequent and often a perplexing symptom; for it may be derived from any portion of the urinary tract as well as from the seminal vesicles or even the epididymis. In most cases hæmaturia is an evidence of a ruptured blood-vessel or of an ulcerated surface in the urinary tract; though in some few cases the blood-corpuscles seem to escape into the urinary channels by diapedesis, without any rupture of vascular walls.

Clinically it is extremely important, though sometimes difficult, to determine the *source* and the *cause* of hæmaturia.

Blood may escape into the urine—

(1.) From the urethra;
(2.) From the neck of the bladder (prostatic urethra);
(3.) From the bladder;
(4.) From the ureter;
(5.) From the pelvis of the kidney;
(6.) From the kidney;

(7.) From the entire urinary tract;
(8.) From the genital tract;
(9.) From sources external to the urinary and genital mucous membranes.

(1.) *Bleeding from the urethra* is a frequent occurrence during the course of gonorrhœa, and is occasionally observed in gleet, and from stricture. The diagnosis as to source and cause is easy, since the blood is mixed with pus. If the blood escape from some portion of the mucous membrane anterior to the membranous urethra, it escapes constantly and can be pressed out; if the source of the blood be in or posterior to the membranous portion, on the other hand, blood escapes only during the act of micturition, since the circular muscular fibres of the membranous urethra by their tonic contraction occlude the urinary channel.

Bleeding may also occur from injuries by instruments, from forced coitus, and from polyps in the urethra. These tumors are probably responsible for urethral hemorrhage more frequently than is generally supposed; for the existence is seldom ascertained or even suspected during life, though post-mortem examination shows that they are not extremely rare. The writer observed a case of urethral hemorrhage which ceased entirely after the removal of four vascular polyps from the floor of the pendulous urethra.

In a few cases bleeding from the urethra has occurred from the lodgment of urinary calculi and of foreign bodies, such as hair-pins, in the channel.

(2.) *Bleeding from the neck of the bladder* and the prostatic urethra usually occurs only at the end of micturition, and is seldom profuse. It occurs chiefly during catarrh of the prostate, a condition which is often observed in the fifth or sixth week of gonorrhœa, and is indicated by the necessity for frequent urination; prostatitis and prostatic hemorrhage may also occur in those cases of paresis or dilatation of the bladder in which the constant use of the catheter is necessary. In cases of chronic prostatitis following gonorrhœa, blood sometimes escapes spontaneously at the end of urination, but is especially apt to follow the introduction of any instrument into the bladder.

Another cause of hemorrhage from the bladder-neck is the existence of varicosities or "bladder-piles" in this locality. This condition is somewhat infrequent, and is usually found in individuals who suffer also from rectal hæmorrhoids. In a few cases it has been noticed that hemorrhage occurred alternately from the rectal and vesical varicosities (Ultzmann).

Another unusual source of bleeding from the bladder-neck is the existence of fissures at the vesical orifice. In one such case observed by Ultzmann, the fissure was plainly visible upon endoscopic examination.

Urinary concretions in the prostatic sinus, new growths and calculi at the neck of the bladder, may also induce hemorrhage from the prostatic urethra.

(3.) *Hemorrhage from the bladder* occurs in cases of neoplasms, vesical calculi, parasites (bilharzia hæmotobia and filaria sanguinis), cystitis, tuberculous and diphtheritic ulcerations.

(4) and (5.) *Bleeding from the pelvis of the kidney* occurs most frequently from the presence of kidney stones, tubercular inflammation, new growths, and parasites.

(6.) *Bleeding from the kidney* is doubtless the most frequent source of hæmaturia. Foremost among the causes are the various forms of nephritis, and the renal congestion which occurs in so many infectious and constitu-

tional diseases—small-pox, scarlet fever, measles, intermittent and recurrent fevers, erysipelas, scurvy, purpura, etc.; in fact, hæmaturia seems a possible result of a febrile condition from whatever cause.

Obstruction to the renal circulation, venous congestion of the kidney, thrombosis of the renal vein, embolus of the renal artery are all known causes.

Tuberculosis, cancer, abscess, and echinococcus of the kidney have been observed to produce hemorrhage from this organ.

Renal hæmaturia has been observed after the ingestion of irritant substances, such as cantharides, turpentine, mustard, and even quinine. In other cases it occurs in diseases of organs which are not intimately associated with the kidney; thus it has been observed in cirrhosis of the liver. Finally a few cases occur in which blood appears in the urine as the result of exposure to cold; this is a not infrequent cause of hæmoglobinuria, though the cases in which blood-corpuscles escape from the kidney as a result of taking cold are as yet few. Greenhow observed four cases of paroxysmal hæmaturia with simultaneous rheumatic pains and a large amount of oxalate of calcium in the urine. Socoloff reports the case of a Russian officer who during eight years had occasional hæmaturia, which almost invariably followed exposure to cold; the case was especially interesting because the patient exhibited during the hæmaturia paresis and diminished sensibility of the left side, and complained of pain over the left kidney; the sediment contained blood-corpuscles, blood-casts, and renal epithelial cells. Hæmaturia, perhaps with pain in the bladder and groin, is occasionally observed in hot weather, especially in persons not yet acclimated in a given locality. Possibly this is caused by the concentration of urine from excessive perspiration, and consequent formation of small concretions. It is usually relieved by alkalies.

In a few cases renal hemorrhage is reported occurring apparently as vicarious menstruation; in one case a woman seventy-five years of age is said to have had irregular hæmaturia subsequent to the menopause, twenty-six years previously.

(7.) *Hemorrhage from the entire urinary tract* occurs usually in cases exhibiting anomalies of the blood or blood-vessels. In most of these cases hæmoglobin only escapes into the urine, while in some the sediment is found to contain not only the amorphous masses of hæmoglobin but also distinct corpuscles.

A more important class of cases is that in which hemorrhage follows the complete evacuation of a dilated bladder; cases in which hypertrophy of the prostate, stricture, or paresis of the bladder has resulted in permanent distention of this organ with incomplete evacuation of urine. Such a condition is sooner or later followed by dilatation of the ureters, pelves, and tubules of the kidney; this condition usually exists for years before it becomes necessary to employ the catheter; if catheterization be incautiously performed, if the bladder be completely evacuated at one sitting, there occurs a congestion of the blood-vessels in the urinary mucous membrane in consequence of the removal of the accustomed pressure. This congestion often results in cysto-pyelitis and even nephritis; in other cases severe capillary hemorrhage occurs in the different portions of the urinary tract.

(8.) *Bleeding from the genital tract* in the male is usually discovered by the admixture of blood with semen; in some cases tuberculous or calculous inflammation of the seminal vesicles causes an escape of blood which may appear in the urine.

The urine of females often contains blood derived from the uterus or vagina, not only during the menstrual period, but also in the intervals.

(9.) Blood is frequently mixed with the urine from *sources external to the genito-urinary organs.* In such cases there is usually inflammation or abscess in the vicinity of the urinary tract, such as perinephritis or psoas abscess.

To determine the source of the blood which may be mixed with the urine, reliance must be placed chiefly upon the symptoms, and upon the microscopic examination of the sediment; the reaction, color, and specific gravity of the urine furnish presumptive though not conclusive evidence.

The reaction of the urine is usually acid in hemorrhage from the kidney and pelvis, and alkaline in vesical hemorrhage, provided the latter proceed from an inflamed bladder.

The color of the urine in cases of hæmaturia is usually either bright red, dark red, or nearly black. This difference in color indicates merely the length of time during which the blood has been in intimate contact with the urine in the body. For at the temperature of the body the bright red hæmoglobin becomes oxidized by contact with the urine into the brown methæmoglobin, causing a corresponding change in the color of the urine. This brown tint indicates, therefore, that the blood has been mixed with the urine quite intimately for some time; since this mixture occurs in the kidney, and in parenchymatous hemorrhages, the brown color is usually found in cases of renal bleeding. Blood which escapes from the bladder-wall is retained such a short time that this change of color does not occur. In cases of parenchymatous hemorrhage from the bladder, such as results sometimes from cancer and stone, the blood may be so intimately mixed with the urine as to exhibit the change of color to brown.

The specific gravity may also have some diagnostic value in determining the source of a hemorrhage; for in inflammation of the kidney and of the pelvis there is often polyuria with a correspondingly low specific gravity.

Blood-clots are sometimes present and often indicate the source of the hemorrhage; fresh clots are usually formed in the bladder or urethra, while clots of a brown or yellowish color are of less recent origin and may have been formed in the pelvis or ureter. Long, rod-shaped clots of small calibre are formed in the ureters, indicating that the hemorrhage has occurred above these channels.

The microscopic examination of the sediment enables us to distinguish parenchymatous (capillary) hemorrhage from that following rupture of larger vessels with comparative certainty, and since hemorrhage from the kidney is usually capillary, we can usually distinguish renal hemorrhage from that from other sources.

Capillary or parenchymatous hemorrhage is detected microscopically chiefly by one characteristic feature—the varying size and color of the red corpuscles. In hemorrhage from a larger vessel, the blood-corpuscles appear in the urine without greater variations in diameter than we are accustomed to observe in freshly drawn blood; after capillary hemorrhage, on the other hand, the greatest diversity in size of the red corpuscles is observed, varying from the ordinary diameter down to mere granules. These smaller forms appear to be fragments of corpuscles disorganized by the long-continued contact of the urine. Many of the corpuscles have lost their color and are visible only by refraction at the periphery; indeed by applying a weak solution of iodine we can in such cases often bring into

view red corpuscles which had previously escaped notice. Friedreich first pointed out the fact that in cases of capillary hemorrhage, the red corpuscles in the sediment frequently exhibit amœboid movements such as are often manifested by the white blood-corpuscles. It has been found that these movements are excited by contact with urea; hence they are more frequently observed in concentrated than in dilute urines. Since capillary hemorrhage occurs more frequently from the kidney than elsewhere in the urinary tract, these amœboid movements of the red corpuscles are most frequently if not exclusively observed in cases of renal hemorrhage.

The most important characteristics for determining the source and cause of blood in the urine are, however, as already stated, not based upon the appearances of the blood itself, but upon the symptoms presented by the patient and upon the elements other than blood contained in the sediment.

Thus in cases of hemorrhage from the kidney there are usually found blood-casts from the tubules as well as renal epithelium. In such cases it can sometimes be determined that the urine contains a greater amount of albumen than should be furnished by the blood present.

If the hemorrhage be caused by parasites—filaria sanguinis, echinococcus, or bilharzia—evidence of their existence will be found upon careful search in the sediment.

Hemorrhage from the pelvis, if due to renal stones, will usually be accompanied by rough, pointed crystals of uric acid, and sooner or later by pus; if due to tuberculosis, the characteristic bacilli may possibly be found.

Hemorrhage from the bladder is often accompanied by crystals of triple phosphate and urate of ammonia; if from the bladder neck, there may be found mucous casts from the prostatic glands containing pus-corpuscles.

In many cases assistance in diagnosis can be derived from the presence of peculiar epithelial cells. In cases of malignant formation, particles of the growth are often discoverable in the urine.

3. Pus.—The urine may contain pus derived from any part of the genito-urinary tract as well as from abscesses external to this tract; thus abscesses around the bladder, the womb, the rectum, the kidney, in the psoas muscle, in the abdominal wall, in the liver and in the spleen, have been known to break into the pelvis of the kidney, the ureter, or the bladder, and discharge their contents into the urine. The symptoms of the patient and the other elements present in the sediment must be relied upon to determine the seat of suppuration. The pus itself affords but little information in this regard; if the pus-corpuscles are imbedded in mucus so as to make plugs or strings, it may be inferred that the pus is derived from the urethra or from the prostate as a sequel of gonorrhœa, though such threads are occasionally observed in cases of pyelitis. The form of the epithelial cells accompanying the pus may distinguish between the two sources. In ammoniacal urine pus is converted into a slimy, jelly-like mass, usually miscalled mucus.

Tube-casts.

Since the discovery by Henle (1842) that casts of the urinary tubules appear in the urine in various renal diseases, these cylinders have been the object of much study and attention. It was at first supposed that they consisted always of fibrin which had escaped from the blood-vessels during the inflammatory process and coagulated in the tubules; the different ob-

jects often observed upon casts—blood-corpuscles, epithelial cells, and granules—were supposed to be merely entangled in the coagulating fibrin. The casts were regarded as positive proof of renal inflammation.

FIG. 5.—Hyaline Casts, from Renal Congestion (Fürbringer).

Recent investigations have, however, shown that casts arise in different ways, and that some varieties are formed and expelled with the urine even when the kidneys are entirely free from inflammatory action. Etiologically considered, there are three varieties of cylinders: 1, blood-casts; 2, hyaline casts; 3, epithelial casts.

1. BLOOD-CASTS consist simply of blood which has escaped into the tubules and there coagulated; they are found only in cases where free blood-corpuscles are present in the urine; hæmaturia of renal origin and acute nephritis usually furnish these casts (Fig. 6).

2. HYALINE CASTS.—Of these there are two varieties, the very delicate and *transparent* cylinders (Fig. 5) and the thicker and more *opaque* casts (Fig. 7). The latter originate in the epithelial cells.

The delicate transparent hyaline casts are homogeneous and glassy, sometimes containing a few granules or epithelial cells, and usually very narrow (.01 to 1 mm. in breadth). When studded with granules they may be mistaken by a careless observer for "granular" casts—an error to be avoided, since the latter are found only during renal inflammation. The true hyaline are readily distinguished from the granular casts by their extreme delicacy and transparency.

FIG. 6.—Epithelial, Blood, and Granular Casts, from Acute Scarlatinal Nephritis.

3. Epithelial casts appear under three different and distinct forms, which have received different names, but whose significance depends upon the fact that they originate in the epithelial cells. These are: simple epithelial casts (Fig. 6); granular casts (Figs. 6 and 8); opaque hyaline and waxy casts (Fig. 7).

While these represent the three types of epithelial cylinders, there are found numerous transitional and mixed forms (Fig. 7).

The *simple epithelial* casts are composed of epithelial cells which have been detached from the basement membrane of the tubule and expelled unchanged, so that the outlines of the individual cells and often their nuclei are distinguishable.

Fig. 7.—Epithelial, Amyloid, and Fatty Casts and Swollen Epithelial Cells, from Chronic Parenchymatous Nephritis.

The *granular* casts are formed by a metamorphosis of the epithelium, whereby the outlines of the cells and their nuclei are but indistinctly if at all visible, the cells being replaced by masses of granules. These casts are often of irregular outline, fissured, of a dark brown color, and thickly studded with dark granules.

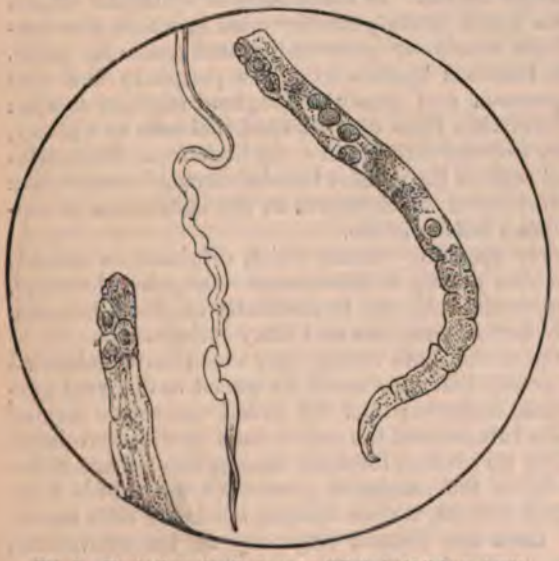

Fig. 8.—Finely Granular Casts and a "Cylindroid," from Acute Nephritis.

A still further metamorphosis of the epithelium results in the production of *the opaque hyaline casts.* These are readily distinguished from the transparent hyaline casts (which are of different origin) by their thickness, opacity, strong refractive power, and frequently by a yellowish color. In a few cases they produce the amyloid reaction with iodine. These thick casts of waxy appearance are often fissured and frequently accompanied by masses of swollen epithelial cells.

Casts of all varieties may contain, entangled in their substance, various foreign elements, such as blood-corpuscles, individual epithelial cells, fat-granules and drops, bacteria, and various urinary salts, amorphous or crystalline (urates, uric acid, calcium oxalate, etc.).

The term *cylindroid* has been applied (Thomas) to very long and narrow casts, which are, however, really mere modifications of the delicate hyaline casts (Fig. 8).

Origin of Tube-casts.—The *transparent hyaline* casts are composed simply of coagulated albumen which has undergone some as yet unknown modification, since they exhibit reactions different from those shown by serum albumen, globulin, and fibrin. They are formed entirely from the serum of the blood, and may therefore appear in the urine in any case in which serum albumen is found, even though there be no disease of the kidney whatsoever. Weissgerber and Ribbert have produced hyaline casts experimentally by simple pressure upon the renal vein or occlusion of the renal artery; they are also produced by such artificial elevation of temperature as suffices to cause albuminuria. Under these circumstances the epithelium of the tubules exhibits no abnormal appearance, but their lumina become filled with finely granular albumen, which after a time is transformed into perfectly hyaline casts of the tubules.

These experimental researches are in perfect accord with the clinical observation that hyaline casts may appear in the urine during any of those conditions already enumerated which induce albuminuria independent of renal disease; hence alone they do not constitute the slightest evidence of Bright's disease.

The *epithelial*, *granular*, and *opaque hyaline* casts are composed of the epithelial cells of the tubules, either unchanged or (in the two latter varieties) metamorphosed. In the first-named variety the outlines of the cells and nuclei are distinctly visible. In many casts of epithelial origin, however, the cells coalesce into a finely granular mass in which the contours of cells and nuclei are nearly or quite obliterated (granular casts). At a later stage the mass becomes hyaline from the periphery and may ultimately appear homogeneous and glassy throughout (opaque hyaline casts). Indeed, the transformation from distinct epithelial cells to a glassy, homogeneous mass appears to occur directly in some instances. This metamorphosis of the epithelial cells in the urinary tubules during inflammation is analogous to the transformation which occurs in the epithelium of mucous surfaces during croupous inflammation.

Epithelial casts, properly speaking—those which originate in detachment of the tubular epithelium during inflammation—comprise, therefore, not only those in which epithelial cells can be distinctly outlined, but also those which are commonly termed granular and waxy cylinders.

Since different casts even of the same variety vary much in diameter and in shape, it has been supposed that they could be traced to different portions of the tubules by these features; that the broad casts were formed in the wider portions of the tubules and the spiral casts in the convoluted tubules. There is, however, no ground for such assumption; there is, indeed, no means for identifying the particular portion of the tubule from which a given cast has been derived, unless distinct epithelial cells are attached. Probably most casts are formed originally in the convoluted tubules.

It has been asserted that so-called "secretion casts" are produced in normal kidneys by the exudation of plasma from the tubular epithelium. This certainly occurs in certain non-inflammatory conditions of the kidney,

where the urine contains an excess of urates or has a high specific gravity (1030 or more) but no albumen; possibly this exudation is caused by irritation of the tubular epithelium. These cylinders are generally included under the name "mucous casts," though most of the objects so called are casts of the spermatic tubules.

Amyloid casts seem to arise either from hyaline or from epithelial cylinders; they are found in cases of nephritis as well as in pure amyloid degeneration of the kidney. They do not, therefore, necessarily indicate a degeneration of the epithelium, though found also, as already stated, in cases where such degeneration has occurred.

Fatty casts are either hyaline or epithelial casts which are studded with oil-globules produced by fatty degeneration of the renal epithelium; they are usually derived from the cells of the tubules, and hence are properly included in the group of epithelial casts.

Mucous casts is a term applied to objects derived from several sources. Under this head have been described: 1, cylindroids, which are really extremely long and slender hyaline casts; 2, secretion casts, which are formed (probably from an exudate of the epithelial cells) in the tubules of normal kidneys, especially under the influence of irritation by urinary salts; 3, most of the so-called mucous casts are derived not from the kidney at all, but from the spermatic tubule. All these varieties, generally termed mucous casts, are remarkable for their extreme length, transparency, and slight refractive power.

The clinical significance of tube-casts varies according to the variety and number present, as has been already indicated. Transparent hyaline casts do not necessarily prove the existence of Bright's disease, since they may be found in any case of albuminuria from whatever cause, independent of renal disease. They are found in the urine in febrile conditions, in obstruction to the systemic circulation such as occurs in diseases of the heart and lungs, in cases of long-continued or intense excitement, etc. They are also found in cases of actual disease of the kidney, especially in cirrhosis of that organ and in the acute nephritis which follows scarlatina and other infectious diseases.

The presence of epithelial casts, on the other hand—the term including the granular, fatty, and broad opaque hyaline varieties—indicates a disintegration of the renal epithelium, and therefore nephritis.

An opinion as to the degree and duration of renal inflammation can be based upon the number and kinds of casts present, especially when taken in connection with the history and symptoms. The number of casts depends largely upon the amount of urine excreted, for oliguria is frequently accompanied, either as cause or result, by a retention of the casts in the tubules. It is quite probable that the rapid formation of numerous casts in the kidney may materially diminish the excretion of urine. Free diuresis, on the other hand, is usually accompanied by the expulsion of numerous casts.

In acute nephritis blood-casts, epithelial casts with well-defined cells and nuclei, and broad opaque hyaline casts are especially numerous; in the chronic forms, the granular, hyaline, and fatty casts predominate. The other morphological elements found with or upon the casts are also significant; thus numerous leucocytes are found during acute inflammation, large drops and masses of fat during chronic nephritis, etc. In most cases in which epithelial, granular, or hyaline casts are found in the urine, albumen is also present. Yet it is a fact of the utmost clinical importance that disintegration of the renal epithelium resulting in the formation of casts may occur without albuminuria; *the absence of albumen does*

not, therefore, prove the absence of renal disease. Thus in cases of nephritis following scarlet fever, it is not rare to find hyaline and epithelial casts without a trace of albumen in the urine; and in cirrhosis of the kidney granular and hyaline casts are sometimes seen even when the urine is entirely free from albumen. In other cases hyaline casts are observed in non-albuminous urine, apparently without renal disease, or at most with hyperæmia of the kidney. This is frequent in cases of icterus (Vallin); indeed, Nothnagel discovered that casts appear in every case of intense icterus in which the urine contains the biliary acids, though in many of these instances no albumen is present. Experimentally it has been demonstrated that the injection of the biliary acids into the circulation causes the formation of tube-casts, with or without albuminuria. Fischl has often seen casts in the urine, usually of the hyaline though sometimes of the epithelial variety, during ordinary intestinal catarrh; in many cases no albumen was discovered.

This disintegration of the renal epithelium without albuminuria has been observed experimentally as well as clinically; it has been produced by the injection of biliary acids and by the introduction into the circulation of renal irritants such as cantharides and turpentine (Schachowa). These substances are known to cause necrosis of the epithelium in the convoluted tubules without at first affecting the glomeruli; herein lies doubtless the explanation of the appearance of epithelial casts without albuminuria.

Besides the tube-casts proper, there are found in urine masses of material resembling them in shape and size, because moulded in the urinary tubules; some of these may be produced independently of renal disease, though often combined with genuine casts of renal origin.

Uric acid and urates are often observed in the urine in the form of tube-casts. In most of these cases this form is of artificial origin, caused by the rolling of the cover glass over the slide during the preparation of the sediment. In nursing children, however, who are known to suffer from uric acid infarct of the kidney, these cylinders are evidently produced in the tubules. They are composed of reddish-brown granules and balls, sometimes as large as blood-corpuscles, imbedded in a mass resembling mucus.

Casts of biliary pigment are sometimes seen in cases of icterus caused by occlusion of the biliary ducts. Möbius found by the examination of kidneys in such cases that the glomeruli were always free from biliary pigment, but that the epithelium of the convoluted tubules and of Henle's loops was filled with granules of bile pigment; he observed, furthermore, in the lumen of the tubules numerous cylinders of a roughly granular appearance, composed of biliary pigment. This fact explains the clinical observation that in such cases oliguria and even anuria may occur —the result evidently of the plugging of the urinary tubules by the biliary pigment. These casts of bile pigment often appear in the urine without albumen; sooner or later, however, albuminuria usually occurs in these cases, accompanied by hyaline and even epithelial casts in the sediment.

Casts composed of bacteria, or thickly studded with these organisms, are often found in cases of suppurative nephritis (surgical kidney) and of pyæmia; in a few cases of erysipelas and diphtheria also they have been seen. In these cases the appearance of bacteria in the form of tube-casts is quite comprehensible, since the organisms are found in the blood and in the kidneys during these diseases. Recently Litten has described two cases in which the occurrence of casts composed of bacteria is not so

The first case was that of a girl nineteen years of age who had previously enjoyed good health. After slight indisposition for several days she suddenly exhibited severe abdominal symptoms—pain, vomiting, and profuse diarrhœa accompanied by chills and fever (the temperature re aching 41° C.); the urine became very scanty, 100 to 200 c.c. daily, and contained much albumen and remarkably broad casts studded with micrococci. Death occurred in three days from uræmia. The section revealed enlargement, congestion, and cloudy swelling of the kidneys; microscopically there were observed irregular local dilatations of the tubules in both cortical and medullary substance. These dilated tubules contained masses of micrococci; the epithelium was in many places filled with the same organisms. Similar masses of bacteria were found in the capsules and capillaries of the glomeruli and in the vasa afferentia; there was, in addition only a slight interstitial nephritis. Litten observed a second case with essentially similar history.

Casts from Organs other than the Kidney.—There are frequently found in the urine microscopic cylinders resembling in their general outline those formed in the renal tubules; these are derived either from the prostate or from the testis.

Prostatic casts are found occasionally in cases of chronic catarrh of the prostate subsequent to gonorrhœa. They are moulds of the prostatic follicles, usually much broader than the renal casts, and commonly studded with pus-corpuscles; they occur in groups and are accompanied with epithelial cells from the prostatic urethra. Their composition appears to be simply mucus.

Casts of the seminal tubules are occasionally encountered in the urinary sediment. They can often be recognized at once by the fact that spermatozoa, or fragments of them, are found imbedded in the casts; otherwise they may be called mucous casts from the kidney. They are very long, transparent, and delicate.

Spermatozoa.—These cells are found in the urine not only after coition, pollutions, and in spermatorrhœa, but also after epileptic seizures. In spermatorrhœa there are occasionally found partly developed spermatozoa.

Urine which contains semen sometimes exhibits also minute bodies which resemble grains of sago; these are masses of albumen derived from the seminal vesicles.

Fragments of Morbid Growths.—New formations in the bladder and urethra can occasionally be recognized by the discovery of fragments in the urine; neoplasms of the kidney and pelvis, on the other hand, are rarely revealed in this way.

Extreme care must be exercised in deciding upon the origin of individual cells found in the urine; in fact, it is practically impossible to recognize any single cell as a so-called "cancer cell." For the normal epithelium of the urinary tract furnishes cells of great diversity in shape and size; caudate and spindle cells are present normally in the ureter, urethra, and bladder. If many of these be present, remarkable for their large size and atypical shape as well as for the size and number of their nuclei, a suspicion of a morbid growth may be entertained if the symptoms corroborate such assumption. Yet such great diversity of size and shape of the epithelial cells is witnessed during a simple inflammation of the bladder, that great reserve must be exercised in basing an opinion upon such data. It is quite otherwise, however, when fragments of neoplasms are found in the urine. These may be derived from a cancer or from a papilloma (villous cancer) of the bladder. In the case of carcinoma, fragments of the

tissue appear in the urine only after ulceration has begun, by which time the symptoms and the persistent hæmaturia have usually rendered the diagnosis almost certain; it occasionally happens, however, that the symptoms are so obscure as to puzzle even the experienced surgeon until a piece of the growth is observed.

Fragments of papilloma, on the other hand, are often obtained early in the course of the disease; indeed, it has repeatedly happened that by the introduction of a catheter a piece of an unsuspected papilloma has been withdrawn. This growth presents under the microscope a characteristic appearance, resembling a tree in its outline; each branch consists of a broad blood-vessel upon which rests a single layer of columnar epithelium.

Entozoa.—Four animal parasites of the body occasionally give evidence of their presence by the appearance of the sediment. These are:

1. *Echinococcus;* the hooks and even fragments of the enclosing sac may appear in the urine when a cyst located in or near the kidney has burst into the pelvis.

2. *Strongylus gigas*, a nematode worm, occasionally makes its home in the human kidney, though it is far more frequently found in the kidney of the dog. In a few rare instances the eggs and even the adult worms are said to have been found in human urine. It is probable, however, that the diagnosis was erroneous, the worm having been actually an ascaris from the rectum, which much resembles in appearance the strongylus. The latter is distinguished from the ascaris by the possession of six papillæ around the mouth, while the ascaris has but three.

3. *Distoma hæmatobium*, or *bilharzia hæmatobia*, is a trematode which makes its home in the veins of the pelvic organs, especially the bladder and the rectum. The parasite lays numerous eggs in these vessels whereby the vascular channels are occluded, causing hemorrhage and ulceration. It is found almost exclusively in Africa, especially in Egypt; cases in which it has been observed in America appear to be exclusively individuals who have resided in Africa. Such a case came under the writer's observation in February, 1883, in which the urine contained numerous eggs and much blood.

4. *Filaria sanguinis hominis* appears in the urine soon after entering the body. At first the only symptom to direct attention to the urine may be hæmaturia; after a time chyluria occurs, the urine now containing masses of fibrin which may seriously impede the evacuation of the bladder. If these masses of fibrin passed during the night be separated into fragments and examined microscopically, one or more of the embryo worms can usually be found; sometimes specimens are observed disentangled from the fibrin and blood. This parasite also appears to be indigenous to tropical countries; it has been found in India, China, Egypt, Brazil, and Australia. But few cases have been observed in Europe and America, and these exclusively in persons who have resided in one of the countries named.

In addition to these four worms which are parasitic in the urinary organs or in the blood, other animals occasionally find their way into the urinary organs and are discharged with the urine. The most frequent of these is perhaps the thread worm so common in the rectum during childhood; these not only drop into the vessel, but may even crawl into the urethra in the female.

In other cases abnormal communication is formed between the intestine and the bladder, through which worms inhabiting the former organ find their way into the urine. One such case is reported in which an individual had several times observed worms issuing from his urethra. At

the age of twenty-eight he was operated upon for stone, and died five days later. The section showed that the vermiform appendix had become adherent to the bladder and that a fistula existed between the two organs, closed by a valvular fold of mucous membrane.

Fungi.—After exposure to the air there are often found in urine several varieties of fungus, chiefly the yeast or sugar plant and the penicillium glaucum. They are especially prone to develop in slightly acid, concentrated urine. The sugar fungus occurs with especial frequency in saccharine urine, merely because the presence of the sugar renders the urine a favorable soil for the growth of the plant. So far as is at present known, these fungi are never present until after the urine has left the body; they occur more frequently in albuminous than in non-albuminous urine.

Quite otherwise, however, is the significance of the sarcina urinæ. This fungus, like the sarcina ventriculi, occurs in groups of two, four, eight, etc., but is smaller than its namesake from the stomach. It is seen but rarely in the urine, but when present evidently proceeds from the bladder, where it often occasions a troublesome and obstinate affection. The plants grow in the bladder for weeks or even months, in spite of all treatment, but finally disappear from causes as yet unknown. The patient meanwhile suffers from a low grade of cystitis; the urine presents a thick flocculent sediment, containing the organisms. Attempts to plant sarcinæ in the bladders of healthy dogs and rabbits by injection into the bladder and into the jugular vein have always failed (Welcker, Leube). There must evidently be some influence which predisposes the urine and the bladder for the reception of these organisms. In some cases reported the catheter had been previously employed, so that there was a possibility that the plants had been introduced into the bladder in this way; in other cases no instrument had ever been introduced into the bladder, so that the mode of access of the sarcina remained unexplained.

Bacteria.—These organisms, like the other fungi already mentioned, are found in urine after it has been exposed to the air for a short time. Since they are present in the body during many pathological conditions, and since they are usually so small as to pass readily through capillary walls, they often enter the urine before it leaves the body. They have been found in freshly voided urine in the following conditions:

In various infectious diseases accompanied by the presence of bacteria in the blood and tissues; thus the characteristic bacilli have been found in the urine in cases of anthrax, the spirilla of Obermeier in relapsing fever, micrococci in the various forms of septic infection—pyæmia, diphtheria, ulcerous endocarditis, etc. In most cases these organisms seem to have passed from the blood through the glomeruli into the tubules, and appear scattered in the urine. In many cases of septic infection, however, the micrococci are found in masses, usually in the shape of tube-casts, showing that they were growing rapidly in the tubules. Microscopic examination of the kidneys from such cases proves that micrococci frequently invade the tubules as well as the vessels of the kidney.

In the majority of diseases already referred to, the diagnosis is easily made without an examination of the urinary sediment; but a few cases are on record in which an invasion of the kidneys by micrococci has occurred without inducing characteristic symptoms, and in which the diagnosis has rested upon the appearance of bacteria in the shape of tube-casts in the urine. Reference has been already made to two recent cases reported by Litten.

In the pathological conditions already discussed, the bacteria are car-

ried to the kidney in the blood; there is, however, a class of cases in which they gain access to the kidney by continuous growth from the bladder along the ureter. Such are cases of surgical kidney or suppurative nephritis, following operations upon the bladder and urethra, or consequent even upon the simple introduction of a catheter into a chronically distended bladder. In these cases, too, the invasion of the kidney by bacteria is indicated by the appearance of casts composed of these organisms in the urine.

There is, moreover, a class of cases in which bacteria are constantly present in the bladder, where they have been introduced by means of catheters. So long as the vesical mucous membrane retains its normal condition and the bladder evacuates itself completely, ordinary bacteria at least do not find a favorable soil for propagation in this organ. Many observers have repeatedly injected fluids containing ordinary bacteria, even putrid liquids, into the bladders of healthy animals; but in every case these liquids and the contained bacteria have been promptly expelled without causing inflammation. It is quite otherwise, however, if the bladder fail to evacuate itself completely, so that a certain amount of urine is always present in the organ; for the bacteria of putrefaction, introduced under such conditions, find a favorable soil in the stagnant urine and propagate within the bladder. Thus it happens that in cases of elderly men who in consequence of prostatic hypertrophy, vesical paresis, or other cause, fail to evacuate the bladder completely, the urine soon becomes turbid after the introduction of the catheter. This turbidity is due to the presence of bacteria which are introduced with the unclean instrument and establish themselves in the stagnant urine of the bladder. In this way a previously existing cystitis is aggravated, or an inflammation is induced where none existed prior to the introduction of the instrument.

In a few cases Roberts and Fürbringer have seen an inexplicable "bacteruria." The urine contained great numbers of these organisms, whose source could not be ascertained; it emitted an offensive odor, but retained its acid reaction an unusually long time. The complaint, often accompanied with temporary irritability of the bladder, lasted intermittently for years.

Bacillus of Tuberculosis.—This organism has been repeatedly found in the sediment from cases of tuberculous disease of the kidney and pelvis. If present the bacilli are found in the pus derived from these tuberculous lesions; a drop of the sediment is prepared upon cover-glasses in the same manner as sputum.[1]

The unanimous experience of all investigators, clinical and pathological, has shown that these bacilli are never found in lesions other than tuberculous; hence the presence of these organisms in the urine may be regarded as absolute proof of tuberculous disease in the urinary or genital tract. The exact location of the lesion must, of course, be determined by the other characters of the urine as well as by the symptoms of the patient.

While the presence of the bacilli proves tuberculosis, it is not true that their absence excludes tuberculosis. It has been already discovered that in many miliary tubercles no bacilli can be detected: indeed, cases of tuberculosis are on record in which competent observers have failed to find the bacilli anywhere in the tissues. Hence it may be inferred that tuberculosis of the genito-urinary tract may exist without the occurrence

[1] For particulars, see author's Cartwright Lectures for 1883, p. 126. W. T. Keener, Chicago.

of bacilli, at least in discoverable numbers, in the urine. My own experience supports this inference; for in two cases in which the symptoms and the urine indicated tuberculosis of the bladder-neck, I was unable to detect the organisms in the sediment, although I had considerable experience in the requisite manipulation, and had often discovered them in sputum, tissues, and pus from other sources.

Leptothrix, a fungus which seems to belong to the family of bacteria, has been in two cases found in freshly voided urine. In one instance, observed by Küssner, the patient was a diabetic whose urine contained brownish masses composed of leptothrix threads enclosing epithelial cells from the bladder. This phenomenon persisted some weeks, until death; the section showed a normal bladder containing similar masses of leptothrix threads. No information as to their mode of ingress was obtained. In the second case the fungus was derived from the præputial sac, where a mass of the threads was discovered.

Accidental ingredients of various kinds are often observed in the urine. Some of these are intentionally introduced by hysterical patients; indeed, such individuals sometimes deceive the physician by introducing blood as well as foreign bodies into the urine. In examining the urine from a female the possibility should always be borne in mind that blood, pus, and epithelium observed may be derived from the vagina.

Abnormal communication between the urinary tract and various organs sometimes permits the entrance of foreign bodies into the urine. Gallstones have been found in the bladder and voided with the urine, having entered the urinary tract through a fistula from the intestine or from the biliary duct. Güterbock recently performed lithotripsy and found that the nuclei of the stones were biliary calculi.

Hairs have been occasionally voided with the urine. These are derived from various sources, being sometimes intentionally introduced into the bladder (by women); in other cases the hairs have been derived from dermoid or ovarian cysts which had opened into the bladder; in these instances other animal tissues, such as teeth and bones, have also been evacuated with the urine. Martini recently observed a new-born child with atresia of the urethra and anus; the posterior wall of the bladder presented the structure of normal skin and was provided with fine hairs; Martini regarded the case as one of superfœtation. There is as yet no case recorded in which an otherwise normal bladder produced hairs.

CHAPTER XVII.

CLINICAL EXAMINATION OF THE URINE.

As ordinarily practised, even in the examination of applicants for life insurance, the analysis of the urine includes little more than the determination of reaction, specific gravity, and the presence or absence of albumen and sugar. Such an examination is always incomplete and often misleading; for it frequently fails to reveal abnormality of the kidneys or other organs which are actually present, and, on the other hand, often leads to a diagnosis of renal disease or diabetes where none actually exists.

Now a thorough examination of the urine, quantitative as well as qualitative, is, of course, too complicated and delicate a process for ordinary clinical use; yet by a judicious use of a few ordinary reagents a far more accurate and intimate knowledge of a patient's condition can be derived from the urine than is usually obtained. Even without the microscope many pathological conditions, both of the kidneys and of other organs, can be recognized or at least strongly suspected.

The following method of examination is used by the writer in ordinary clinical work. While it makes no pretensions to mathematical accuracy nor to quantitative completeness, it nevertheless furnishes all the information required for diagnostic and prognostic purposes, and can at the same time be executed so easily and speedily that it is perfectly practicable for clinical use.

When possible, the specimen for examination should be *mixed* urine—that is, should be taken from the entire quantity passed during twenty-four hours. Since this is often impracticable, at least two specimens should be obtained on each day, one passed upon rising in the morning and the other voided during digestion at noon or night. The latter specimen, it should be remembered, may contain albumen, though none is found in the urine at other times. The urine secreted during digestion should be neutral or alkaline; decided acidity of such urine indicates an abnormally acid excretion. Before conclusions are drawn, however, the physician should assure himself that the bladder has been emptied shortly before digestion began. He should also inquire whether the patient is taking medicine or drinking mineral waters which may materially influence the character of the urine.

In many cases it is desirable to have the urine passed at one urination into two different vessels; an ounce or two, first passed, should be received into one vessel while the remainder is voided into a second. In this way we are often enabled to locate an existing suppuration, hemorrhage, or catarrh in the urethra or at the neck of the bladder. If it be desired to obtain the urine unmixed with the secretions of the bladder and urethra, a soft catheter may be introduced and the bladder thoroughly and repeatedly washed out, after which the urine that escapes through the catheter is comparatively free from the undesired admixture.

If the urine be turbid, the turbidity should be removed (after its cause

is ascertained) before applying chemical tests. A turbidity due to urinary salts, pus, and epithelium can be removed by simple filtration. A cloudiness due to bacteria which cannot be removed in this way can often be cleared up by shaking the urine with magnesia usta, or with a solution of lead acetate—one part to eight of water—and filtering or permitting the precipitate to fall. The lead also precipitates the sodium chloride and causes the urine to simulate the sugar reaction with caustic potash (Heller's test).

For microscopic examination the urine should be permitted to stand twelve to twenty-four hours in an ordinary bottle; the conical glasses so much employed are undesirable, since much of the sediment adheres to the sloping sides. If immediate examination be necessary, the sediment may be collected by filtering through fine paper.

The examination of the urine includes:

A. The *determination of the quantity excreted in twenty-four hours.* This amount should be ascertained not for one day only but for each of several days at intervals.

B. The *reaction* and *color.*

C. The *cause of the turbidity,* if any exist.

D. The *specific gravity.* This has often but little value unless the quantity of urine excreted in twenty-four hours is known.

E. The *appearances produced by contact of nitric acid.* This acid reveals: 1, albumen; 2, excess of urates; 3, excess of urea; 4, excess of indican; 5, biliary pigment; 6, blood-pigment; 7, vegetable coloring matters; 8, iodine; 9, excess of carbonates; 10, propeptone.

F. *Effects of heat.* This alone reveals: 1, albumen; 2, earthy phosphates.

G. *Effects of caustic potash and heat.* This combination reveals: 1, sugar; 2, biliary pigment; 3, blood-pigment; 4, vegetable coloring matters; 5, uroerythrine.

By these simple means—litmus paper, a urinometer, nitric acid, heat, and caustic potash—we can speedily and conveniently detect any abnormality of the urine of clinical importance, so far as this can be done without the microscope. It is of course necessary, in case certain abnormal features are discovered—such as the presence of sugar or blood—to employ confirmatory tests.

A proper interpretation of the results obtained by the reagents above mentioned depends upon the following facts:

A. The *quantity* of urine excreted in twenty-four hours taken in connection with the *specific gravity* furnishes valuable information. Polyuria, with a low specific gravity (1010, for example), may result from transient causes such as the ingestion of large quantities of water; it is also observed in cases of hysteria, of diabetes insipidus, of pyelitis and cirrhotic kidney. Persistent polyuria with high specific gravity is rarely found except in diabetes. Oliguria with high specific gravity is the rule in febrile conditions in cases of diarrhœa or profuse perspiration. Oliguria with low specific gravity is usually, when persistent, indicative of chronic nephritis.

By means of the specific gravity and the quantity of urine we can estimate with considerable accuracy the total solids and the urea excreted. The last two figures of the specific gravity are multiplied by two (if below 1.018); if 1.018 or above, by $2\frac{1}{3}$. The product represents the total solids in grammes contained in 1,000 c.c. (32 ounces) of urine.

Thus if a patient pass 40 ounces (1,200 c.c.) of urine in a day, specific gravity 1,020, the estimation of the solids is made as follows: $20 \times 2\frac{1}{3} = 47$,

the number of grammes in 1,000 c.c. of urine; in the total quantity, 1,200 c.c., there are of course contained $\frac{6}{5}$ of 47, or 56 grammes.

Since the urea usually constitutes by weight about one-half of the entire solids of the urine, this calculation furnishes an approximate estimate of the amount of urea excreted, which would be in the above case 28 grammes.

B. The *color* and *reaction* of the urine are noted together, since the significance of the color is often explained by the reaction.

Pale, almost colorless urine of *neutral reaction* is often excreted during various neuroses, especially hysteria.

Dark yellow or *reddish-yellow* urine, of *acid* reaction, is usually observed during febrile conditions.

Dark brown or *reddish-brown* urine, of *acid* reaction and *transparent*, contains hæmoglobin; if of *neutral* or *alkaline* reaction and *turbid*, it contains blood or biliary pigment. A similar appearance may be caused by the excretion of carbolic acid by the kidneys.

Bright red urine of *alkaline* reaction usually contains not blood but vegetable coloring matter, especially chrysophanic acid derived from rhubarb or senna; the addition of an acid changes the color to yellow; an excess of an alkali restores the red color. A similar reaction is produced by santonin, gamboge, madder, and logwood.

A *dark brown* or almost black color is sometimes observed in cases of melanotic cancer.

Dirty green urine is excreted during jaundice from obstruction; the reaction varies.

Dirty blue urine, of acid reaction, usually contains an excess of indican.

Many urines, especially those of children, exhibit a gradual darkening in color upon standing for a few hours; the cause of this phenomenon is unknown.

C. *Turbidity* of the urine is caused by urates, phosphates, blood, pus, mucus, or bacteria.

Heat dissolves the urates.

The addition of a few drops of acetic acid dissolves the phosphates.

Turbidity caused by blood or pus is unchanged or increased (through coagulation of albumen) by heat or an acid.

A cloudiness due to bacteria is persistent.

E. The application of *nitric acid* is a most important item in the examination, and no less important is the manner in which the acid is introduced. A test-tube containing urine to the depth of two inches is held obliquely, and pure nitric acid is permitted to flow down the side until it forms a layer half an inch in depth at the bottom of the tube. The zone of contact of urine and acid presents different appearances according to the composition of the urine:

A *light brown* color is seen in normal urine.

A *more intense brown* color is observed in concentrated and in febrile urine.

A *white cloud* indicates either albumen, propeptone, urates in excess or resins (copaiba, etc.). The distinction between these is simple; the cloud of albumen appears just at the line of contact between acid and urine, and is of uniform depth throughout. The cloud of urates is formed a little above the surface of the acid; it appears only after the lapse of some seconds, and forms not a ring of uniform thickness but a cloud which curls upward at the centre somewhat like ascending smoke; it disappears upon warming. The resins disappear at once upon the addition of a little

alcohol. Propeptone forms a cloud resembling albumen, which disappears, upon heating to 170° F., with the production of an intense yellow color; upon cooling the precipitate reappears. It is dissolved in an excess of acid.

A *reddish-brown* ring at the line of contact indicates blood-coloring matter; in most cases albumen is of course also present, so that there is formed a reddish-brown cloud.

A *bright green* ring is produced by biliary pigment before it becomes oxidized.

A *brilliant blue* or violet results from an excess of indican.

A *brown* zone is produced if the urine contain iodine.

An *excess of urea* (four or five per cent. or more) is indicated by the gradual formation, in the course of three to five minutes, of crystals which project into the layer of acid, and are thus distinguished from the cloud of urates, formed under similar circumstances, which are visible above the acid.

An *excess of carbonates*, such as may occur from the use of mineral waters, is indicated by sparkling or even effervescence.

If upon the addition of the acid a bright-red alkaline urine becomes colorless or yellow, the presence of *vegetable coloring matters* is indicated. After neutralizing with an alkali the red color returns.

By means of nitric acid we can not only detect the presence of albumen, but also estimate with considerable accuracy the quantity present. This quantitative estimation is based upon the appearance of the cloud at the line of contact:

A *faint white ring*, distinctly visible only against a black background (such as the coat-sleeve), indicates from one-tenth to one-fourth per cent. of albumen.

A *distinct white ring*, easily seen without a black background, exhibiting numerous granules and small lumps, indicates from one-fourth to one-half per cent. of albumen.

The presence of *large lumps and flakes*, some of which fall to the bottom of the tube through the acid, indicates from one-half to two per cent. of albumen. The quantity rarely exceeds two per cent. except in cases of amyloid kidney or acute nephritis.

This method of estimating the quantity of albumen present in the urine is extremely simple and convenient for clinical purposes, and fairly accurate.

F. *Effects of heat.* Urine is poured into a test-tube to the depth of two inches; if neutral or alkaline, two or three drops of acetic acid are added. The reaction should be *faintly* acid.

A *white cloud* observed upon boiling may be albumen or earthy phosphates and carbonates; the latter are redissolved upon the addition of a few drops of acetic acid.

A *previous turbidity* may disappear upon warming, in which case it was due to the urates; if it increase, it is due to the phosphates or to blood, pus, or mucus; if it remain unchanged it is due probably to bacteria.

G. A *solution of caustic potash* (one part to three of water) is added, in quantity sufficient to equal one-half the bulk of the urine in the test-tube. Upon boiling, a heavy sediment falls, consisting of the earthy phosphates; in normal urine this sediment is about one centimetre thick, if the urine have been poured in to the depth of two inches.

A *white appearance* of the phosphates occurs in normal urine.

A *red or violet* color of the sediment indicates vegetable coloring mat-

ters, usually chrysophanic acid. If *brown*, the urine may contain bile-pigment. A *gray* color indicates uroerythrine.

A *rust* color is produced by blood.

The color of the supernatant urine after boiling with the caustic potash solution may be as significant as the color of the sediment. A *yellow*, *yellowish-brown*, or *blackish-brown* shade indicates sugar. It is found that sugar to the amount of one per cent. causes the urine to assume under these circumstances a canary color; two per cent., a dark amber color; five per cent., a Jamaica-rum color; and five to ten per cent., a dark, almost black color, so intense that the urine no longer appears transparent. The addition of a few drops of nitric acid bleaches this dark urine and causes it to emit an odor of molasses. This color-test for the presence of sugar is usually applicable, since the original color of the fresh urine in cases of diabetes is generally very light.

By means of heat, nitric acid, and caustic potash, therefore, any ordinary abnormal ingredient dissolved in the urine and possessing clinical significance can be detected. A positive result by these reagents should be confirmed by special tests; if no indication of abnormality is furnished, the physician may confidently dispense with further tests and pass on to the microscopical investigation of the sediment.

Tests for Sugar.—The ordinary tests for sugar are so cumbersome that they are rarely employed in practice unless a suspicion of diabetes is entertained; and they are so liable to mislead, in consequence of the disturbing influence of various urinary constituents and the instability of the tests, that the results obtained are often incorrect. The popular copper test is among the least reliable, since the solution decomposes and gives a reaction with an excess of uric acid; moreover, it fails to detect glucose when the amount is less than one grain to the ounce. There is therefore a large field for a sugar test which is at once delicate, reliable, and stable. Such a reagent seems from present indications to have been found in the

Picric Acid Test.—When picric acid is heated in an alkaline solution of glucose, picramic acid is formed, giving to the liquid a deep reddish-brown or garnet color. This reagent possesses the great advantage that it is a test for albumen as well as sugar; hence both of these substances can be detected simultaneously by a single manipulation. Now glucose is frequently found, not only in urines of high specific gravity (with which we are accustomed to associate it in our minds), but also in comparatively light and even very dilute urines; glycosuria is indeed by no means rare. Hence it is recommended that the picric acid test be employed in examining every urine as a test for both sugar and albumen.

This double test is made as follows: to about two inches of urine in a test-tube there is added an equal volume of a saturated solution of picric acid. If serum albumen be present a turbidity appears which is increased by boiling. About one inch of liquor potassæ is then added to the boiling mixture, whereby the albumen if present is redissolved. The boiling is continued for a minute; a pronounced dark-red or brown color indicates the presence of sugar. If the urine contain two grains or more to the ounce, the mixture becomes quite black (Johnson).

It is to be noted that a slight darkening of color is produced during this test in perfectly normal urine, but the presence of the minutest trace of sugar (as revealed by other reagents) produces a decided change of color such as is never observed with normal urine. The physician should therefore familiarize himself with the effect of this test upon normal urines before employing it for the detection of sugar.

A deepening of color, simulating the sugar reaction, is produced by tannin, ferrous salts, and creatinine in excess. Hence it is desirable to confirm the result by the use of a second reagent.

Fehling's test, modified by Professor W. S. Haines, of Rush Medical College, Chicago, is the best of all the copper tests for sugar, having the unusual advantage of stability. The following formula and directions for use are kindly furnished by Professor Haines:

Pure sulphate of copper	30 grains.
Pure glycerine	2 drachms.
Pure caustic potash—in sticks	1½ "
Pure water	6 ounces.

Dissolve the sulphate of copper and glycerine in a portion of the water, and the caustic potash in the remainder; mix the two solutions, when a perfectly clear, transparent, dark-blue liquid should result, which may be bottled and set aside for use. As usually made it generally throws down a slight reddish deposit upon standing a week or two. This, however, does not affect its value as a test; in using, simply decant the clear liquid from the sediment.

Directions for Use.—Take a drachm or two of the test solution and gently boil it, when no change should take place; now add six or eight drops of the suspected urine and again boil. If sugar be present an abundant yellow or yellowish-red precipitate is thrown down; if sugar is not present, no such precipitate appears, but the color of the test solution will be rendered somewhat lighter and often of a greenish or even of a greenish-yellow shade, by the dilution of the blue test-liquid with the yellow urine. A white flocculent deposit of phosphates, coming from the urine employed, is often seen floating about in the fluid, and should not be mistaken as a reaction for sugar.

Care should be taken not to use more than six or eight drops of the suspected urine; this quantity will be amply sufficient to show the presence of sugar, if it exist in such an amount as to be of any clinical significance; while the addition of a larger quantity of urine, whether it be normal or saccharine, will sometimes lead to results extremely perplexing to those inexperienced in the use of the test.

A few drops of honey, dissolved in an ounce of urine, produces an artificially saccharine urine, which may advantageously be employed by the beginner to learn the exact reaction produced by diabetic urine in the above test.

Tests for Peptone.—The most satisfactory method for the clinical detection of peptone in the urine is made with Fehling's solution or Haines' modification. This is poured into a test-tube to the depth of an inch, and an equal bulk of urine is floated upon the top. In normal urine a zone of phosphates is formed at the junction of the two liquids; if peptone be present this zone acquires a reddish or pink tint. If there be also a considerable quantity of albumen in the urine, the red acquires a violet hue. Additional proof of the presence of peptone can be obtained by now dropping into the liquid a drop or two of concentrated picric acid solution; the original red tint becomes deeper, then reddish-yellow, and finally yellow.

Tests for Biliary Pigment.—So long as the biliary coloring matter in the urine remains unoxidized, it can be detected with great certainty; after oxidation, however, its detection is less positive.

Gmelin's Test.—Strong nitric acid, which should contain also some

nitrous acid (indicated by red fumes) is poured down the side of an inclined test-tube containing the suspected urine. At the zone of contact there occurs from below upward a series of colors—green, blue, violet, red, and yellow—if bilirubin is present. In many cases the blue and violet are not observed; in fact, the green is the most prominent and indispensable in the recognition of biliary pigment.

Nitric acid without the admixture of nitrous acid sometimes fails to reveal biliary pigment; if pure nitric acid be permitted to stand in the sunlight for some days, the red color indicative of nitrous acid becomes apparent in the bottle.

Heller's Test.—Pour into a test-tube about two drachms of pure hydrochloric acid and drop into it just sufficient urine to impart a distinct color to the acid. After stirring, the mixture is underlaid with pure nitric acid; at the zone of contact there occurs a play of colors. If the contents of the test-tube be now thoroughly mixed with a glass rod, the same play of colors is observed throughout the entire mixture. This is the most generally applicable test for clinical use. The presence of albumen does not impair the value of the test; indeed, almost the only possibility of mistake results from the presence of indican in excess, whereby a blue, violet, and red color may be produced; the green, however, is lacking, though the admixture of the yellow urine with the blue color of the indican may suggest a green tint.

Ultzmann's Test.—To three drachms of urine add one drachm of pure caustic potash solution (one part of potash to three of water); shake well, and add an excess of pure hydrochloric acid. The mixture assumes a brilliant emerald-green color.

After the decomposition of the biliary pigment, there is no certain means for its detection. Probably the best method consists in the addition of one volume of caustic potash solution to two volumes of urine; a dark color indicates the presence of biliary coloring matter. If upon the addition of a few drops of sulphuric acid this dark color is much deepened, the presumption is strengthened.

Tests for Indican.—The simplest is Heller's, which answers for most clinical purposes. A drachm of pure hydrochloric acid is poured into a test-tube, and a few (five to twenty) drops of urine are added with constant stirring. In normal urine the mixture assumes a yellowish-red color; if an excess of indican be present, a blue tint becomes apparent, its intensity increasing with the quantity of indican. This reaction sometimes requires from five to fifteen minutes. By adding a drop or two of nitric acid, the test is made more delicate.

The presence of albumen may mislead, since this substance produces with hydrochloric acid a faint-blue color. It is, therefore, necessary to remove albumen by boiling and filtering the urine.

If biliary coloring matters are present, they should be removed by precipitation with acetate of lead solution (one part to ten of water).

Jaffe's test, modified by Salkowski, is somewhat more complicated, but less liable to mislead. Equal parts of urine and strong hydrochloric acid are thoroughly mixed in a test-tube; a saturated solution of chloride of lime is then added drop by drop until an intense blue color is developed. A few drops of chloroform are added and the test-tube is shaken; the blue pigment (indigo) is dissolved by the chloroform, which settles to the bottom, leaving the urine colorless. In performing this test, albumen should be first removed, and highly colored urine decolorized.

Test for Chlorides.—It is sometimes clinically important to know

whether or not the chlorides are excreted in increased quantity; not that such excess has in itself especial diagnostic value, but because such knowledge enables us to infer whether or not urea is present in normal amount. For since the urine is practically a solution of urea and the chlorides, a normal quantity of the latter with a low specific gravity indicates a deficiency of urea.

To two inches of urine in a test-tube add three or four drops of nitric acid (to prevent precipitation of the phosphates) and then one or two drops of a nitrate of silver solution, one part to eight of water. In normal urine a white curdy precipitate is formed and falls readily to the bottom; if the chlorides are decreased in quantity, no curdy masses are produced, but only a general turbidity.

Quantitative Estimation of Urea.—A knowledge of the quantity of urea excreted in the urine has seldom any especial clinical value. For, as has been already stated, the excretion of urea is so largely dependent upon the quantity of nitrogenous food ingested, that the amount of the latter must be carefully determined before inferences as to the extent of tissue metamorphosis are warranted. It is chiefly in cases of chronic nephritis that the clinical estimation of urea has diagnostic or prognostic value; if the excretion of urea is persistently much less than the average amount (thirty to forty grammes) an impairment of the renal activity may be inferred with much confidence.

The simplest way for estimating the quantity of urea excreted consists in estimating the total solids in the urine from the specific gravity, by the method already mentioned, and in determining the quantity of chlorides with nitrate of silver solution. A persistently low excretion of solids without any deficiency in the chlorides indicates a diminished excretion of urea. Yet this is a decidedly crude and unreliable method of arriving at the amount of urea excreted, and until recently there was no accurate method of sufficient simplicity for clinical use.

In 1877 Dr. George B. Fowler, of New York, submitted a method to which was awarded the prize of the Alumni Association of the College of Physicians and Surgeons, New York. This method has been extensively tested since that time, and has been found to be accurate and trustworthy. The process is based upon two facts: first, that the decomposition of urea lowers the specific gravity of the urine; and second, that there is a definite relation between the decrease of urea and the decrease in specific gravity. It was found that a decrease of one degree in the specific gravity as indicated by the urinometer was produced by a loss of $3\frac{1}{2}$ grains of urea per ounce, that is .77 per cent. of the urine. The method, therefore, consists simply in noting the specific gravity before and after the addition of an agent which decomposes the urea; the difference between the two multiplied by $3\frac{1}{2}$ gives the number of grains of urea in each ounce of the urine, or multiplied by .77 indicates the percentage of urea contained in the specimen.

To decompose the urea, Dr. Fowler employs either Labarraque's solution or Squibb's chlorinated soda; seven parts of either of these liquids is sufficient to decompose the urea in one part of urine, unless an excessive quantity be present, in which case the urine should be diluted with an equal bulk of water.

Process.—To one volume of the urine add seven volumes of Labarraque's solution; decomposition of urea takes place at once, indicated by effervescence from the liberation of nitrogen. The vessel containing the mixture is shaken a few times at intervals, and allowed to stand for two

hours, at the end of which time the decomposition of urea is accomplished. The specific gravity of the mixture is now noted.

It is also necessary to determine the specific gravity of the mixture before decomposition; this is accomplished by multiplying the specific gravity of the pure Labarraque's solution by 7, adding the specific gravity of the urine, and dividing by 8.

Subtract the specific gravity of the mixture after decomposition from that before decomposition; multiply the difference by $3\frac{1}{2}$ to find the number of grains of urea per ounce of urine, or by .77 to find the percentage of urea.

Illustration.—If the specific gravity of the urine is 1015 for example, and that of the Labarraque solution 1040, that of the mixed fluid before decomposition will be

$$\frac{1040\times7+1015}{8}=1037$$

If the specific gravity of the mixture after decomposition is found to be 1034, then the difference, 3, multiplied by .77, or 2.21, shows the percentage of urea. Or we may multiply 3 by $3\frac{1}{2}$, making $10\frac{1}{2}$, the number of grains of urea in each ounce of urine; this multiplied by the number of ounces excreted in twenty-four hours shows the total excretion of urea for the day.

In performing this test, only two precautions need be taken: first, the specific gravities of the different liquids should be taken at the same temperature and at the same time; hence it is advisable to set aside a bottle of the Labarraque solution and of the urine in the same place as the mixture, and to make the specific gravity of each after decomposition has taken place in the mixture. Second, if the specific gravity of the urine be very high, showing an unusual amount of urea, it is advisable to dilute the urine with its own bulk of water before adding the Labarraque solution; for otherwise some of the urea may escape decomposition from lack of the reagent. In case the urine has been diluted in this way, it is of course necessary to multiply the result indicating the percentage by 2.

This test is not impaired by the presence of albumen or sugar.

Bedside Tests for Urine.

During the last few years certain reagents which had been employed almost exclusively by chemists have been extensively used as clinical tests; and through the happy device of Dr. Oliver, of Harrowgate, they have been rendered available to the general practitioner in the form of bibulous papers impregnated with the various substances required. The reagents thus utilized are five: for detecting albumen, picric acid, potassio-mercuric iodide, sodium tungstate, potassium ferrocyanide; for detecting sugar, picric acid and indigo-carmine.

The advantages claimed are: (1), greater delicacy, and (2) greater convenience (when used as test-papers). That several of these reagents are more delicate than the heat and nitric acid tests, revealing a smaller percentage of albumen, is undoubtedly true; but that this increased delicacy confers any diagnostic advantage, is doubtful. For traces of albumen in the urine, such as can be detected by the potassio-mercuric iodide only, have no pathological significance unless accompanied by other indications of renal or general disease. Indeed, it is the experience of those who have carefully employed these delicate reagents, that traces of albumen are revealed by them in most urines even from apparently healthy persons. Yet

the increased delicacy of these tests will doubtless confer one clinical advantage; the more frequent detection of traces of albumen in the urine will probably lead to the more frequent microscopic examination of the sediment, without which no positive diagnosis of chronic renal disease should ever be made.

The convenience of these tests, in that they can be applied at the bedside, is also an apparent rather than a real advantage. For the detection of albuminuria at the bedside has no other value than as an indication for the necessity of thorough examination of the specimen at the office; and this should be made in every case, whether albumen be detected or not; for a negative result with these test-papers at the bedside does not insure the integrity of the kidneys, nor relieve the physician from the obligation to make a further examination of the urine.

The additional delicacy of these tests confers a value, therefore, in physiological rather than in clinical applications. Yet the use of these test-papers cannot be too emphatically urged upon all physicians who, from lack of time or other cause, are in the habit of neglecting the examination of the urine except in pronounced cases of renal disease or diabetes. As already stated, such examination should be just as essential in every case of disease as the inspection of the tongue or feeling of the pulse; and the general use of these convenient test-papers will certainly further diagnosis and treatment without consuming much time.

All of these reagents used in testing for albumen precipitate also other substances occasionally present in the urine—peptones, urates, mucus, alkaloids, and oleoresins; these are, however, readily distinguished from albumen by the employment of heat, *which clears up all precipitates other than serum albumen.*[1]

The various reagents exhibit different relations toward various substances other than albumen which may be found in the urine. Thus the picric and potassio-mercuric solutions precipitate *alkaloids*, while the tungstate and ferrocyanic tests do not. These tests may, perhaps, enlarge the field of clinical urinalysis by their power of precipitating *propeptone*, which forms a cloud resembling serum albumen, but unlike the latter substance gradually dissolves as the liquid is warmed, and finally disappears at a temperature of about 70° C. Since propeptone is not coagulated by heat, a comparison of tests may establish its presence. Yet the clinical significance of this substance in the urine remains to be determined.

Picric acid is, for certain reasons, an especially valuable test; it precipitates albumen in acid and alkaline as well as in neutral urine. In using the heat test, on the other hand, care must be taken to secure a faintly acid reaction of the urine, since an excess of acid or alkali so transforms serum albumen that it is not coagulated by heat and is doubtless sometimes overlooked. Picrid acid can, moreover, be used as a test for sugar; for this purpose it is most convenient and delicate; both albumen and sugar can be thus detected by a single manipulation, previously described (p. 162).

A comparison of these various tests has given in different hands varying degrees of delicacy. Dr. Oliver reports as the result of his own observations that these different reagents detect albumen as follows: Heat and nitric acid—one part in 6,000 or 7,000 (.02 per cent.); potassium

[1] Such is the general belief and teaching; yet Dr. Robert Kirk states that a precipitate of strychnine by the potassio-mercuric iodide persisted in spite of heat (Lancet, November 17, 1883). At any rate, caution and confirmatory tests should be employed before drawing final conclusions until all peculiarities of these reagents have been ascertained.

ferrocyanide—one in 10,000 or 12,000 (.01 per cent.); potassio-mercuric iodide, picric acid, and sodium tungstate—one in 20,000 (.005 per cent.).

In a recent paper before the New York Academy of Medicine, Dr. G. B. Fowler stated as the result of his observations that the smallest amount of albumen detected by the various tests (the urine having a specific gravity of 1022) was as follows:

	Per cent.
Heat	.2
Nitric acid	.1
Picric acid	.1
Ferrocyanide of potassium	.1
Sodium tungstate	.1
Potassio-mercuric iodide	.01

Dr. C. W. Purdy made a series of observations as to the comparative delicacy of these tests in detecting serum albumen and egg albumen. For the former he finds that the potassio-mercuric iodide and sodium tungstate are "the most delicate and reliable, and possessing the fewest objections;" for recognizing egg albumen, on the other hand, he considers heat and nitric acid preferable to all others.

Dr. Vincent Harris came to the conclusion, after comparative tests, that "the three tests—picric acid, sodium tungstate, and potassium ferrocyanide—are about the most delicate albumen precipitants, and should be reckoned as being about on a par, with preference in favor of picric acid." His experience with potassio-mercuric iodide has been unsatisfactory.

Although the results quoted show much diversity as to the absolute and relative delicacy of the different reagents in detecting albumen (the diversity due doubtless largely to the varying composition of the urine and of the tests employed) yet nearly all agree in demonstrating the relative delicacy of the potassio-mercuric iodide. The writer also can, as the result of personal experience, recommend this test as delicate and reliable.

Use of these Reagents.—These various tests may be employed as solutions, or more conveniently by means of Oliver's test-papers. In using the solutions, care must be taken to add a little acetic or citric acid before introducing the reagent. When this latter is added, a cloud is formed at the zone of contact between the two fluids if albumen or certain other substances are contained in the urine. The test-tube is then heated almost to the boiling point; a cloud which persists upon heating is serum albumen.[1]

In using the test-papers, the acidulation of the urine is first effected by introducing a paper saturated with citric acid. About thirty minims of the urine are introduced into the test-tube; then one or more (if the

[1] On account of their convenience the test-papers are preferred for these reactions; and I would cordially recommend the pocket-case containing these papers and other conveniences, which is prepared and sold at a low price by Messrs. Parke, Davis & Co., of Detroit. Provided with this case even the busiest practitioner can make a fair physical and chemical examination of the urine in every case which he attends.

The solutions are made as follows:

Potassio-mercuric iodide. 3.22 grammes of potassium iodide and 1.34 grammes of mercuric bichloride are dissolved in 100 c.c. of distilled water and filtered.

Sodium tungstate. A saturated solution of this salt (about one part to four of water) and another of citric acid (five parts in three of water) are mixed in equal volumes. Since this test solution contains free acid, it is not necessary to acidulate the urine before testing.

The potassium ferrocyanide reagent consists of a saturated solution of this salt.

Picric acid is employed for testing as a saturated solution made with boiling water, and containing about seven grains to the ounce.

urine be alkaline) citric-acid papers are pushed into the tube, so as to produce an acid reaction. Sometimes a turbidity is observed around the paper; this is produced by the urates and uric acid, mucin, or oleoresins. Upon heating the turbidity disappears unless it is caused by mucin, which is therefore detected by citric acid and heat.

After the effect of the citric-acid paper has been noted, one of the papers containing the precipitant of albumen (any one of the four named) is introduced. A cloudiness produced may be due to peptones, alkaloids, etc.; such turbidity disappears upon heating; if it persist, the cloud is composed of albumen.

The papers may also be used as follows (Oliver): "Those who prefer to develop a zone of precipitation along the plane of contact of a test solution and the urine can do so with these papers as follows: put the reagent paper with fifteen minims of water in one test-tube and a similar quantity of the urine with a citric-acid paper into another. When the reagent is dissolved, a portion of the solution is taken up with a pipette and allowed to trickle down the side of the tube, in which it will either glide over the urine, or collect below it."

Since the potassio-mercuric iodide is the most sensitive reagent, it may be used first; for a negative result by this test indicates certainly the absence of albumen. The reaction is often transient, since the iodide soon decomposes in the acid urine, liberating free iodine, which colors the solution and obscures traces of albumen.

The sodium tungstate test is nearly as delicate as the former, and does not cause the precipitation of alkaloids, though it produced a cloudiness with peptones. Hence a urine which becomes turbid with the iodide paper, but remains clear with sodium tungstate, *probably contains alkaloids.*

The potassium ferrocyanide is considered less delicate than either of the former; but as it does not precipitate either alkaloids or peptones, it is less liable to mislead during a hasty or careless examination. Dr. Oliver recommends it to those who have had but little experience in the use of urinary tests.

By using these three tests in succession, *peptones* and *alkaloids* can be recognized with considerable probability; for *the iodide precipitates, both* the *tungstate peptones only*, and the *ferrocyanide neither.* Hence a urine which becomes cloudy upon the addition of each of the two former tests, but remains clear when the ferrocyanide paper is introduced, *probably contains peptones.*

Picric acid has, as already stated, the advantage that it produces a reaction with both sugar and albumen.

In using these reagents it must never be forgotten that the test is not complete until the liquid has been heated almost to the boiling point; since the persistence of the cloud when heated is the decisive proof that it is composed of albumen.

Tests for Sugar.—The two reagents—picric acid and indigo-carmine—used for this purpose must be employed in connection with an alkali, preferably sodium carbonate. They are not interfered with by the presence of albumen and of urates in excess.

To make the picric acid test, twenty-five minims of water and three grains of sodium carbonate are put into a test-tube with one of the picric-acid papers; then ten minims of the urine are added, and the liquid boiled for fifty or sixty seconds. If sugar be present the mixture darkens rapidly, often exhibiting a dark-red color. In this case the test should be

repeated with smaller quantities of urine—five, three, and even one minim. If a single minim produces a decided darkening and reddish tinge, the quantity of sugar is probably five or more grains to the ounce.

It is to be remembered that normal urine treated in this way produces a perceptible darkening of the liquid; hence the physician should familiarize himself with the reaction of normal urine before drawing conclusions from this test. Since, moreover, an excess of creatinine may simulate exactly the sugar reaction, a confirmatory test should be employed.

A more trustworthy reagent is that with indigo-carmine. One of these papers and a sodium carbonate paper are placed in a test-tube with forty minims of water; the liquid is then heated until it acquires a pale-blue color. A drop of the suspected urine is then introduced and the heating continued, care being taken not to agitate the liquid nor to permit active ebullition. If sugar be present the liquid will in the course of a minute present a succession of colors—violet, purple, red, orange, and finally straw color. After cooling and shaking these various colors are exhibited in reversed order, finally terminating in the original blue. The delicacy of the test is increased by using an additional paper saturated with carbonate of sodium.

If no change is produced by a single drop of the urine, a second should be added and the process repeated. If only a trace of sugar be present, the change of color will not proceed to yellow, but will stop at one of the intermediate shades.

It is to be noted that normal urine produces a similar reaction when present in larger quantity (five to ten drops). When, however, only one or two drops of the urine have been added, the succession of colors above mentioned may be regarded as positive proof of glycosuria. Care should also be taken not to agitate the fluid during the process, since the contact of oxygen retards or even prevents the change of color.

CHAPTER XVIII.

DISEASES OF THE KIDNEY.

Venous Congestion.

Etiology.—Venous congestion of the kidney is a *symptom*, resulting either from local obstruction to the escape of blood, or from failure of the general arterial circulation. Most cases are included in the latter category, and are incidental to diseased conditions of the circulatory or of the respiratory organs. Valvular heart disease, especially stenosis of the mitral or aortic orifice, are, except during the stage of compensatory hypertrophy, accompanied by arterial anæmia and venous hyperæmia; degeneration of the heart muscle, pericarditis, aneurism of the aortic arch and extensive atheromatous degeneration of the arteries, are among the conditions which may seriously impede the arterial circulation and therefore favor general venous congestion.

The various affections of the respiratory organs which interfere directly or indirectly with the action of the heart may, by their effects upon the circulation, cause venous congestion; among these are emphysema, chronic bronchitis and interstitial pneumonia, chronic pleurisy, as well as nearly all the acute affections of the respiratory tract. It is an unusual feature in phthisis, probably because of the coincident anæmia.

Local impediments to the return of blood from the kidney are rare. In a few cases venous renal congestion has been observed as a result of thrombosis of the inferior vena cava above the entrance of the renal vein; also from compression of this vein by tumors, ovarian cysts, ascites, etc. The renal congestion which accompanies pregnancy is doubtless in some, though not in all, cases the result of the pressure upon the vena cava by the gravid uterus. Thrombosis of the renal vein itself occurs not infrequently in nurslings and sometimes in adults as a result of general marasmus.

Morbid Anatomy.—The anatomical appearances vary according to the duration of the renal congestion. In the early period the kidneys are enlarged, so that upon cutting open the capsule the organ protrudes. The stellate veins of the surface are much distended, and on the cut surface there are numerous dark spots produced by dilated blood-vessels; the Malpighian tufts are distinctly visible as dark red spots.

If the renal congestion have lasted for some weeks, the kidney is found to be hard as well as enlarged; this condition has been termed the "cyanotic induration." At a still later stage, the organ shows signs of atrophy; the cortical portion has become very narrow, and the epithelium as well as the glomeruli are degenerated. The kidney is anæmic, pale, and extremely hard. This hardness is explained upon microscopic examination

by a decided increase in the interstitial connective tissue; here and there the renal structure has been replaced by connective tissue. The contraction of this tissue results in cicatricial depression of the surface, forming scars to which the capsule is quite firmly adherent, so that its removal often tears the kidney tissue.

Symptoms.—The diagnosis rests partly upon the recognition of disturbances in the circulatory or respiratory organs, and partly upon abnormal conditions of the urine. A feeling of weight and tension over the kidneys, increased upon pressure, is an occasional symptom. At a later stage some swelling of the feet, even pronounced dropsy, occurs and persists until compensatory hypertrophy of the heart is established (in cardiac disease). The condition of the urine varies according to the cause of the congestion: if this be the result of some local impediment to the return of blood which does not interfere with the arterial supply to the kidney, the urine is usually increased in quantity, contains a large percentage of albumen, usually also some blood and a few hyaline tube-casts (Fig. 9). If the congestion be, as it commonly is, the result of failure of the arterial circulation, so that the blood-supply to the kidney is diminished, the urine is much decreased in quantity, of dark color, acid reaction, high specific gravity, and precipitates a heavy reddish sediment (urates). Albumen is present in small quantity or may be absent entirely.

FIG. 9.—Sediment from a Case of Venous Congestion of the Kidney, caused by Mitral Stenosis and Insufficiency; containing a Hyaline Cast, Renal Cell, and Blood-corpuscles (Eichhorst).

Venous congestion of the kidney, when it results from valvular heart disease, is sometimes complicated by embolus and infarct; such complication may be indicated by severe pain in the loin, often accompanied by chill, fever, and vomiting; the urine may be suddenly decreased in amount and always contains a considerable admixture of blood.

Diagnosis.—A frequent error in diagnosis is to assume the existence of nephritis. Many of the symptoms of renal inflammation are often present; for the cardiac or pulmonary difficulty upon which the renal congestion depends, often produces œdema of the feet and legs, catarrh of the stomach and intestine, palpitation of the heart, and shortness of breath—frequent symptoms of nephritis; and the mistaken diagnosis is fortified in many medical minds by the appearance of albumen and casts in the urine. Now nephritis may occur in the course of venous congestion; indeed, this condition seems to predispose to actual inflammation. But it will be observed that the advent of nephritis is accompanied by the appearance of epithelial and granular casts in the urine, while the percentage of albumen is increased and the specific gravity diminished. So long as the albumen is found in small quantity (one-fourth per cent. or less), and the specific gravity remains above the normal, while only hyaline casts are present

in the sediment, it is practically certain that no nephritis exists, and that none of the serious complications of renal inflammation, such as uræmia, need be feared. For it is not until atrophy of the kidney has begun—indicated by the appearance of granular and even epithelial casts in the urine—that an impairment of the renal function occurs as the result of venous congestion; and even then the solid constituents of the urine are usually excreted in normal quantity, notwithstanding the oliguria. The dropsy of chronic nephritis is diffuse, while that of simple congestion is localized in the feet and legs.

The diagnosis of Bright's disease is often erroneously made where there exists no inflammation, but simply venous congestion of the kidneys; it has been my fortune to see several cases of such Bright's disease cured by the timely administration of digitalis. It should be remembered that not only in cases of pronounced cardiac disease, but even in less serious affections of the heart and lungs, albumen, hyaline casts, and blood will probably be found in the urine as a direct result of circulatory disturbance.

If in the course of venous congestion of the kidney, embolism occur, the difficulty of diagnosis from actual nephritis is increased. For such embolism usually causes the escape of considerable blood with the urine, giving it the dark smoky appearance often observed in acute nephritis. Moreover, the patient may experience sudden pain over the kidney and suffer from chill, fever, and vomiting. The distinction may be possible upon the following considerations: embolism occurs in the course of valvular disease of the heart; the pain is sudden and sharp; the amount of blood in the sediment is much increased, while the albumen and casts remain essentially as before.

Treatment.—Since venous congestion of the kidney is merely a symptom, the treatment must be directed primarily to the relief of the original affection. In all or nearly all cases two remedies are required, digitalis and an alkaline diuretic; the acetate or citrate of potassium, or an alkaline mineral water combined with digitalis, materially improves the condition of the urine and the state of the patient. To reduce a decided dropsy, diaphoresis may be employed as directed in the treatment of acute nephritis; it may even be necessary to employ mechanical means, such as Southey's tubes, for removing the fluid from the subcutaneous tissue.

These patients are usually anæmic and may be benefited by iron and quinine. Medicines should be administered in small doses, since there frequently exists catarrh of the stomach and intestine, as a result of which digitalis in ordinary doses produces vomiting and purging, and other remedies are not well borne. Yet it is necessary to secure the introduction of a considerable quantity of digitalis into the circulation; if the frequent repetition of a small quantity (five drops of the tincture) occasion distress, the remedy should be administered as a poultice or fomentation over the loins.

In recent years, several drugs have been recommended as means for reducing the excretion of albumen in various renal difficulties; prominent among these are convallaria majalis, adonis vernalis, and caffein. None of these has, however, realized the hopes entertained for them; indeed, their value seems extremely doubtful.

Ischæmia of the Kidney.

Venous congestion of the kidney may persist for a long time without degeneration of the renal structures, if the arterial supply of blood is not materially impaired in quantity or quality. An interference with this arterial supply, however, whether with or without venous congestion, causes rapid degeneration of the epithelial cells, of the tubules, and of the glomeruli. Such deterioration of the blood exists in various anæmic and cachectic conditions, such as malaria, syphilis, and phthisis, but to a much greater extent in those states which include a disintegration of blood-corpuscles—chlorosis, leucæmia, pernicious anæmia, and above all Asiatic cholera. The same condition results from sudden profuse hemorrhage and from chronic intestinal catarrh; it may often be observed in the exhausting summer diarrhœa of children.

While ischæmia of the kidney usually results from some disturbance of the general circulation, it is known to occur also in consequence of local interference in the renal circulation. This is frequently observed in cases of lead colic, during which contraction of the renal arteries occurs. It also takes place, according to Cohnheim, in puerperal eclampsia; and Leyden has demonstrated that renal ischæmia is an occasional consequence of pregnancy.

Morbid Anatomy.—Renal ischæmia is manifested by pallor of the cortex; after longer duration, when fatty degeneration has occurred, by a yellow color. At times this color is diffuse, involving the entire cortex, while at other times the yellow color is visible only in spots or streaks, indicating local degeneration. The medullary portion usually presents a marked contrast in color, since it is dark red or purple in consequence of venous congestion.

Microscopically, there is observed fatty degeneration of the epithelium, especially in the convoluted tubules and the glomeruli. In ischæmia of high grade, the interstitial tissue of the kidney usually contains a number of white and red blood-corpuscles, though no vascular rupture can be detected.

Symptoms and Course.—Ischæmia of the kidney is in most cases an accompaniment of general ischæmia, which is indicated by constitutional symptoms. The only features directly connected with the kidney are oliguria, albuminuria, and the presence of hyaline casts in the sediment. It is usual to find in cases of cachexia from malaria or syphilis, from chlorosis, after profuse hemorrhage, etc., traces of albumen and a few hyaline casts. These latter are sometimes provided with fatty granules, oil-drops, or even disintegrated epithelial cells. If the condition be persistent, there may also be found in the sediment numerous red and white blood-corpuscles and epithelial cells from the renal tubules and pelvis of the kidney. The quantity of blood is sometimes so great as to give a dark red or brown color to the urine.

It has been repeatedly observed that in ischæmia of the kidney, tube-casts are the only sign of the condition found in the urine, and *that they are present when no albumen can be detected.*

Another observation is the frequent occurrence of indican in excess.

Prognosis.—The course of the renal affection depends largely upon the cause and the duration of the constitutional condition. If the cause be only transient, such as profuse hemorrhage, the symptoms of renal difficulty may subside, though uræmia is possible; if the renal disturbance results from a persistent cause, actual nephritis often occurs, even though

the original difficulty be ultimately removed. Thus lead poisoning and pregnancy are sometimes the starting-point for chronic and fatal nephritis.

The *treatment* is of course to be directed entirely to the cause of the circulatory disturbance.

Atrophy of the Kidney.

Atrophy of the kidney—that is, degeneration of the epithelium and obliteration of the glomeruli—can occur, as already stated, as the result of persistent venous congestion, which causes increase of connective tissue and the so-called cyanotic induration. In this condition the kidney often presents its normal size or even a considerable enlargement.

Atrophy of the secreting elements, accompanied by decrease in the size of the organ, is most frequently met as the result of an inflammatory condition usually termed chronic interstitial nephritis. But an almost precisely similar appearance, microscopic as well as macroscopic, is encountered without the clinical history and the morbid changes in other organs usual in cases of cirrhotic kidney; this simple, non-inflammatory atrophy occurs in old age, apparently as a part of the general atrophy to which senile tissues are prone. The autopsy of aged persons, even those who have never exhibited symptoms of renal affection, usually reveals small, hard kidneys, whose capsules adhere with more than the usual tenacity, and whose surfaces are marked with depressed scars, to which the capsule is firmly adherent. Microscopic examination shows a slightly increased amount of connective tissue, a granular degeneration of epithelial cells, an increased thickness of the Malpighian capsules, and a transformation of numerous glomeruli into homogeneous balls, impermeable to blood.

This senile atrophy of the kidney usually attracts no attention during life, since it does not occasion any of the symptoms which direct suspicion to the renal function. An examination of the urine sometimes reveals traces of albumen with occasional hyaline or granular casts. The quantity of urine is apt to be diminished, by which feature the suspicion of renal cirrhosis, aroused by the presence of albumen, can be allayed. If there happen to be cardiac hypertrophy from some other cause, polyuria may also exist, in which case the distinction of simple senile atrophy from renal cirrhosis becomes difficult.

Since this condition of the kidney appears to be a natural, or at least inevitable, result of old age, no treatment directed to the kidney is required or profitable.

Amyloid Degeneration of the Kidney.

Although the amyloid degeneration of the kidney is frequently found as a complication of renal inflammation, and is usually described as one of the forms of Bright's disease, yet it is etiologically quite distinct from nephritis, and is merely a local manifestation of a general disease. Since it is desirable to eliminate so far as possible all the non-inflammatory affections of the kidney from the conception of Bright's disease, I consider it advisable to discuss this degeneration with the other non-inflammatory changes; even though uncomplicated amyloid change in the kidney is comparatively rare, the degeneration being generally accompanied by chronic nephritis.

Etiology.—Amyloid degeneration is almost invariably a sequel to either chronic suppuration, chronic tuberculosis, syphilis, or scrofula. As to the connection between these pathological conditions and the formation of amyloid matter, we have no definite information, but only theories more or less unsatisfactory. In perhaps the majority of cases chronic suppuration, especially as it accompanies pulmonary consumption or caries of bone, pre-exists. Yet suppuration in any tissue, even as in ulcers of the leg or of the intestine, in cancer of the womb, etc., seems sufficient to induce the formation and deposit of amyloid material in the kidney. While the evidence of such amyloid change is usually apparent only after suppuration has long existed, yet a few instances are recorded in which it seems to have occurred within three months (Cohnheim) and even in eighteen days (Bull) after pus formation had begun. It is sometimes observed in adult life in individuals who had suffered from scrofulous suppuration of glands and bones in childhood; and it is found post-mortem where no suppuration is or has been apparent. The first symptoms have been observed in occasional cases after the primary affection has been healed and suppuration has ceased.

Bartels emphasizes the statement that the existence of chronic suppuration is not of itself sufficient to induce amyloid change unless the suppurating surface be in contact with the air; and assumes that the peculiar proneness of scrofulous and syphilitic suppuration to cause amyloid degeneration is explained by the fact that suppuration due to these taints so frequently occurs as ulceration upon the skin and mucous membranes. He says: "Caries of the vertebræ may lead to extensive destruction of tissue, resulting in the formation of enormous burrowing abscesses, and yet amyloid degeneration of the viscera does not ensue so long as the pus remains pent up in a large abscess cavity, and has no access to the air." That such cases of chronic suppuration, excluded from, as well as exposed to the air, do occur without amyloid degeneration, is unquestioned; but that access of the air is not essential to the occurrence of such degeneration is equally true. For example, I recently made at the Cook County Hospital the autopsy in the case of a woman, twenty-eight years old, who had presented the symptoms—general dropsy, albuminuria, hyaline casts, etc.—which led to a diagnosis of chronic parenchymatous nephritis of "idiopathic" origin. There was found no nephritis, but exquisite amyloid degeneration of the kidneys and spleen, the result of caries of the dorsal vertebræ, from the second to the ninth inclusive. The posterior mediastinum was filled with cheesy pus; no communication existed between the abscess and the surface; indeed no suspicion of the spinal caries had been entertained during life.

Syphilis and tuberculosis appear to be direct and immediate causes of this degeneration, since this is often observed in such cases without the intervention of chronic suppuration. It appears probable that even congenital syphilis may produce the same result.

The cause of the amyloid degeneration is evidently not a local condition of the kidney, but a general morbid state manifested in the blood; for it affects different organs—the liver, spleen, lymphatic glands, intestinal canal, suprarenal capsules, and thyroid gland—as well as the kidneys. The spleen seems especially susceptible, sometimes showing the degeneration where none exists in other organs. It is doubtful whether the kidneys alone are ever the subject of this degeneration, notwithstanding Rosenstein's assertion that such was the case in about seven per cent. of his cases.

Numerous instances of amyloid degeneration are recorded in which none of the usual causes were found to exist, and whose origin is still unexplained. If all kidneys removed post-mortem be subjected to the iodine test, a surprisingly large percentage is found to exhibit the amyloid reaction.

This degeneration is observed more frequently in males than in females, and may occur at any period of life.

Morbid Anatomy.—Since the amyloid change is usually a complication of chronic nephritis, the appearances observed in most cases in which such change is apparent are those of renal inflammation. When uncomplicated amyloid degeneration is met with the kidneys are found to be normal or enlarged, the size depending less upon the degeneration than upon the other changes present. The capsule is easily separated, leaving the surface remarkably smooth, pale, and waxy looking. Upon cutting open the organ, the same waxy appearance is manifest, especially in the cortical substance; the pyramids are frequently deeply injected, presenting a striking contrast in color to the pallor of the cortex. The Malpighian tufts are often prominent as gray translucent points, which have been likened to drops of dew.

Although the gross appearance of the organ is characteristic in an advanced stage of the degeneration, yet the critical test consists in the application of iodine or of aniline (methyl or gentiana) violet, to microscopical sections. The iodine solution should contain three grains of iodine and six of the iodide of potassium in an ounce of distilled water. The aniline test consists of a one per cent. solution of methyl violet. The latter agent is especially satisfactory in staining microscopic sections; the amyloid material exhibits a bright red, which contrasts strongly with the violet of the remaining tissue.

When the iodine solution is poured over the cut surface in pronounced cases, the Malpighian tufts, which are first and chiefly affected by the degeneration, stand out prominently as dark-brown points; the arterioles leading to the glomeruli may also become visible as brown lines. Examination of microscopic sections stained with aniline violet often shows the amyloid change where none is visible to the naked eye.

Upon microscopical examination it is seen that the capillaries composing the glomeruli present the earliest and most advanced change. These loops lose their characteristic structure and exhibit a peculiar glassy homogeneous appearance; their diameter is increased. At an early stage it is often observed that but a small portion of a single loop presents the brown color after treatment with iodine, the remainder of the tuft appearing about normal. At a later stage the brown color is presented not only by the capillaries of the glomerulus but also by the vasa afferentia, the degeneration evidently proceeding from the glomerulus along the arteriole. It may ultimately involve the vasa recta as well; occasionally in advanced cases the intertubular capillaries exhibit the brown color; these vessels thus degenerated are always larger than normal, the increase in diameter resulting from a thickening of the walls and not an expansion of the lumen, which may be indeed decidedly decreased.

In the majority of cases the amyloid degeneration is confined to the vessels; in some instances, however, it is found to affect the epithelium and even the interstitial connective tissue. As might be expected, the first epithelial cells to exhibit the amyloid change are those covering the glomeruli; next are those lining the straight tubules; the epithelium of the convoluted tubules rarely exhibits the amyloid reaction, but usually shows

a fatty degeneration. The deposit of amyloid matter in the epithelial cells of the tubules causes a decided increase in size which may much diminish the calibre of these tubules; they also present a glassy appearance similar to that observed in the walls of the blood-vessels. Such epithelial cells are occasionally found in the sediment, where they may be made to exhibit the color reaction with iodine.

In a few cases there have been observed deposits of amyloid substance in the kidney tissue of such size as to be apparent as gray specks to the naked eye. Similar masses have been found in the walls of the renal artery; thrombosis of the renal vein, originating in the infiltration of its walls with amyloid matter, has also been seen. The deposit in the walls of the smaller vessels may result in such contraction of their calibre that injecting fluids cannot be forced into the glomeruli; on the other hand, such injection often succeeds in reaching nearly all of the tufts, even those which exhibit the amyloid change (Münzel).

In microscopic sections of the kidney, casts are frequently observed in the tubules; many of these exhibit the change of color with iodine, indicating their origin in the epithelial cells; indeed, the coalescence of the tubular epithelium into an amyloid cast is occasionally seen.

It has been already stated that fatty degeneration of the renal epithelium, especially in the convoluted tubules, is usually seen in amyloid kidneys; this epithelial degeneration may be so pronounced as to suggest the results of an inflammatory process—nephritis. Since amyloid degeneration is moreover a frequent complication of chronic nephritis, it is often difficult to decide even with the microscope, whether or not there is an inflammatory element in the changes presented by the kidneys. Yet non-inflammatory degeneration alone can result in the appearance of fat in the epithelium and even disorganization of these cells.

Symptoms and Course.—The symptoms of uncomplicated amyloid degeneration of the kidney are found less in the urine than in the patient's general condition. Since the amyloid change is usually consequent upon a prior abnormal condition, such as suppuration or syphilis, the attention is rarely directed to the kidneys until an advanced stage has been attained. It should, however, be a rule to examine at short intervals the urine of every patient affected with any of those abnormalities already enumerated as originating amyloid change. Unless such special examination is made the condition of the kidney is rarely discovered until dropsy occurs, for there are no subjective symptoms characteristic of the complaint, and the urine presents no objective appearances which attract the patient's attention. The dropsy always appears sooner or later, and is at first confined to the feet and legs; indeed, as Roberts pointed out, the dropsy of amyloid kidney spreads by extension from the feet, and does not affect the face and thoracic cavities so often as in chronic nephritis. Before the fatal termination the limbs may be swollen as high as the trunk, in which case dropsy of the peritoneal cavity frequently ensues; indeed, since the amyloid change may affect the liver as well as the kidneys, ascites may be an early symptom. The swelling of the feet and legs in cases of consumption often indicates the development of the amyloid change in the kidneys.

The occurrence of dropsy is usually preceded or accompanied by a decided pallor and waxy appearance of the skin. There are, however, no characteristic changes in other organs significant of amyloid degeneration, unless we except the obstinate vomiting and intestinal catarrh which so frequently occur; these seem to be generally due to the amyloid degeneration of vessels in the intestinal wall. Otherwise the various organs need

present no evidence of abnormality—a fact which is of the utmost importance in differentiating the amyloid degeneration from the inflammatory affections of the kidney. There is as a rule no hypertrophy of the left heart, no increased tension of the pulse nor rise of temperature, no cerebral hemorrhage nor changes in the retina, no uræmia nor serous inflammations, and seldom transudation into the pleural or pericardial sac.

Upon examining the urine the attention is arrested by the presence of albumen in decided quantity—one-half to one, two, or even more per cent.; yet in several carefully observed cases the urine has been occasionally or permanently free from albumen, and has been normal in all other respects.

The daily quantity usually exceeds somewhat the average amount of health, though great variations in this respect occur, dependent upon the condition of the heart, coincident nephritis, diet, etc.; the reaction is acid, the specific gravity somewhat diminished (1.005 to 1.015). The urine is remarkably pale and clear, rarely depositing a decided sediment. The normal ingredients are excreted in somewhat diminished quantity; in a few cases an excess of indican has been detected.

Upon microscopic examination of the sediment there are seen lymph-corpuscles, sometimes blood-corpuscles, epithelial cells from the kidney, and narrow hyaline casts; sometimes also very broad, opaque, waxy-looking casts, which (rarely) exhibit the brown color upon the addition of iodine. A peculiarity of these amyloid casts, less commonly observed in other varieties, is the frequency and depth of the indentations on the sides. The epithelial cells occasionally turn brown when treated with a dilute solution of iodine; before pronouncing these amyloid cells, however, care must be taken to distinguish them from the epithelial cells found in normal urine, which exhibit a brown color upon contact with iodine (Fürbringer).

Diagnosis.—The existence of amyloid degeneration of the kidney can usually be affirmed with confidence if there be dropsy and a highly albuminous, clear urine without the symptoms in other organs characteristic of renal inflammation; the probability is much increased if there have been a pre-existing condition prone to cause the amyloid change. The degeneration is, however, often overlooked, since it may exist without giving rise to the symptoms mentioned; thus there may be no evidence of suppuration, syphilis, tuberculosis, or malaria, the dropsy may appear only late in the disease, and in a few cases no albumen is at any time discoverable, although the post-mortem examination reveals an abundant amyloid deposit.

Pure amyloid degeneration is readily distinguished from renal cirrhosis by the absence of cardiac hypertrophy, increased arterial tension, uræmic attacks, etc., and by the character of the urine. It is, however, often indistinguishable from chronic parenchymatous nephritis. In many cases the two morbid processes coexist in the same kidney; for both are produced by the same causes. A decided enlargement of the liver and spleen constitutes strong presumptive evidence of amyloid degeneration; while if there be no such enlargement and the urine is less profuse, of darker color, of higher specific gravity, cloudy, and deposits a macroscopic sediment containing granular and epithelial casts, the probability is that the kidney is the seat of parenchymatous nephritis; yet even then the existence of amyloid degeneration cannot be disproven.

The difficulties of this differential diagnosis are well illustrated in the observations of Fürbinger upon four cases of consumption.[1] In these four cases there was chronic pulmonary tuberculosis and tubercular ulceration

[1] Virchow's Archiv, Bd. 71.

of the intestine—conditions which especially favor the formation and deposit of amyloid material. In each of the four Fürbringer observed the symptoms which usually characterize such deposit—enlargement of the spleen and liver, the appearance of albumen and casts in the urine, dropsy, etc. Yet at the autopsy amyloid degeneration was found in the kidney in only one of the four cases; in this one the spleen also exhibited the reaction. In the remaining three cases no amyloid reaction could be obtained in any of the organs; in two of these three there was decided parenchymatous nephritis; in the remaining case no evidence of renal disease was recorded. In every case it is to be remembered that renal inflammation and the amyloid change may coexist.

Prognosis.—After attaining a high degree, and involving the spleen and intestines as well as the kidney, amyloid degeneration appears to be inevitably fatal, even though the primary lesion from which it results be cured. At an earlier stage, however, recovery may be expected if the original malady subside. Thus cases of relief from amyloid degeneration of the kidneys following syphilis and malarial influence have been repeatedly reported, after cure of the primary difficulty. Gerhardt considers that recovery is by no means infrequent in children. It must be admitted that the data upon which this possibility of a favorable prognosis is based are not altogether satisfactory; for, as already stated, the ante-mortem diagnosis of amyloid degeneration is frequently erroneous.

In many cases the primary disorder is incurable; under these circumstances the amyloid degeneration is necessarily persistent. In other cases a kidney which was originally merely the seat of the amyloid change may subsequently become involved in parenchymatous inflammation, since the causes which produce the one are often sufficient to induce the other. This complication practically abolishes all hope of recovery, even if the primary difficulty be relieved. The duration, dependent largely upon the nature of the primary affection, varies from a few months to many years.

Treatment.—No means are known whereby amyloid material once deposited can be removed or its further formation directly arrested. The treatment in these cases consists in the attempt to remove the primary morbid condition and to sustain the patient's strength.

Protection, therefore, consists chiefly in prevention; to this end the most careful search should be instituted for the detection and removal of syphilitic, tuberculous, or malarial taints, sources of suppuration, etc.; indeed, the history of previous syphilis in the subject of present amyloid degeneration should induce the administration of the iodide of potassium and mercurials. The predisposing influence of prolonged suppuration should also be taken into consideration as an argument in favor of early surgical interference in cases of caries, hip-joint disease, large ulcers of the leg, etc. The treatment of such cases should therefore include frequent examination of the urine.

Aside from prophylaxis, but little can be done. A nutritious diet, including the free use of eggs and milk, iron, quinine, and cod-liver oil may prolong the patient's ability to resist the disease. A most annoying and exhausting feature is frequently an obstinate diarrhœa; this can be mitigated by laudanum and (according to Bartholow) by Fowler's solution, three drops of which may be administered three or four times a day.

Embolism and Infarct of the Kidney.

The emboli found in the kidney are usually derived from the cardiac valves, and are therefore especially frequent in cases of endocarditis. In septic infection, however, thrombosis of veins is a frequent occurrence, whose sequel may be embolism of the kidney.

The effect of these emboli depends upon their composition and their size; septic emboli cause suppuration and abscesses in the kidney, while simple fibrinous emboli produce only necrosis. Suppurative nephritis is the usual result in cases of septic infection, and hemorrhagic infarct in cases of fibrinous embolism. The latter occurrence is by no means rare: in three hundred cases of endocarditis Sperling found emboli of the kidney fifty-seven times. The left kidney is found to contain emboli more frequently than the right, presumably because the abrupt angle formed by the right renal artery with the aorta protects the right kidney in great measure from these floating masses.

Morbid Anatomy.—The changes occasioned in the kidney by emboli of aseptic origin vary with the size of the obstructed vessel. At least two cases are recorded, one by Cohnheim and the other by Friedlander, in which embolism of the renal artery itself resulted in necrosis of the entire kidney. Emboli of the intrarenal branches cause infarction, the size of which varies with the calibre and position of the artery plugged by the embolus.

As is well known embolism in the kidney causes a wedge-shaped infarct, the apex of which lies in the substance of the organ, while the base is found at the surface. The infarct is sometimes red, its base projecting somewhat beyond the rest of the surface; its substance consists of the renal tissue in a state of fatty degeneration and flooded with blood-corpuscles. At a later stage the entire mass is replaced by connective tissue, finally resulting in a cicatrix causing a depression in the surface of the kidney. This is the hemorrhagic infarct.

The white infarct, originating in the same way, is not hemorrhagic but anæmic; the tissue deprived of its blood supply by the embolus becomes necrotic and undergoes fatty degeneration.

The occurrence of numerous emboli results in the formation of irregular cicatrices, which may cause the kidney to present a lobed appearance.

Symptoms.—In many cases embolism and infarction of the kidney present no characteristic symptoms. Cases are on record in which sudden pain and tenderness in the loin, vomiting, chill and fever have indicated the lodgment of an embolus in the kidney in cases of cardiac valvular disease. These symptoms alone are, however, insufficient to establish a diagnosis, unless the urine furnish confirmatory evidence. Hæmaturia, coincident with the symptoms already mentioned, affords very strong presumption of renal infarction. Exacerbations of the pain and hæmaturia in cases of renal congestion during valvular heart disease are also frequently due to renal embolism, which may be mistaken for acute nephritis.

Treatment.—In the majority of cases treatment is useless; it is only when the pain is severe or the hæmaturia profuse that narcotics and hæmostatics are required.

Diffuse Nephritis (Bright's Disease).

The literature of Bright's disease during the last twenty-five years has been a mass of divergent theories and views as to the etiology and morbid anatomy of the numerous conditions clinically described as Bright's disease. Several distinct types of renal disease have been clinically recognized under this term, but there has been the greatest diversity of opinion as to the interdependence of these various types, as well as concerning the relations between the clinical symptoms and the morbid anatomy. Much research has been instituted and effort expended to establish a distinct connection between the anatomical appearances and the clinical symptoms; as a result numerous types of Bright's disease have been created, chiefly based upon the microscopical researches of enthusiastic investigators. It is now, however, generally admitted that it is clinically impossible to make such fine distinctions between different forms of Bright's disease as would correspond to the different anatomical pictures, both gross and microscopical, presented by diseased kidneys; and pathologists as well as clinicians are now content with the recognition of a few types of nephritis with the understanding that a large number of cases properly so-called present, both clinically and anatomically, features common to two or more of these types.

As now generally understood, the term Bright's disease is limited to the diffuse inflammations of the kidneys, and excludes other conditions accompanied by albuminuria and dropsy; renal congestion and amyloid degeneration, essentially and often entirely non-inflammatory processes, are therefore no longer included under the name Bright's disease, which is synonymous with diffuse nephritis.

Three distinct clinical pictures are recognized, associated anatomically with diffuse nephritis; each of these is regularly accompanied with characteristic morbid appearances. There are, therefore, three types of diffuse renal inflammation: (1) Acute nephritis, (2) chronic nephritis, and (3) cirrhosis of the kidney.

(1.) *Acute nephritis* includes the various more or less hypothetical sub-forms which have been designated the first stage of Bright's disease (Frerichs), desquamative nephritis (Johnson), hemorrhagic nephritis (Traube), catarrhal nephritis (Virchow), acute desquamative nephritis (Bartels), croupous and epithelial nephritis, etc. In thus ignoring the finer distinctions of acute inflammation of the kidney which have been made by different pathologists and clinicians, it is not asserted that such distinctions do not exist, but simply that they are clinically impracticable. Anatomically the disease is not always a unit; it is doubtless true that the epithelium usually shows under the microscope a more decided departure from the norm than the interstitial tissue; it is also true that in many cases a decided desquamation or catarrh of the renal epithelium is apparent, and that a croupous exudation occurs in the capsules of the glomeruli and in the lumina of the tubules. But none of these changes comprises the entire morbid condition, and therefore none justifies an exclusive appellation; moreover, no one of these anatomical characteristics is so intimately associated with a particalar group of clinical features or with an especial etiological influence as to justify a subdivision of the general term acute nephritis.

(2.) By *chronic parenchymatous nephritis* is designated that form of chronic renal inflammation which is ordinarily accompanied with dropsy,

and which furnishes upon post-mortem examination the large white kidney. There has been some dispute as to whether or not it is usually consecutive to acute nephritis. That it is sometimes so is undoubted; but that it is frequently a primary affection, beginning insidiously without the pre-existence of acute nephritis, is now undeniable.

(3.) By *cirrhosis of the kidney or chronic interstitial nephritis* is designated that form of chronic renal inflammation which is generally accompanied during life by disease of the heart and arteries, complications in the serous membranes, the retina, etc., but without dropsy. Upon post-mortem examination the kidney is found to be small, hard, and often granular.

The greatest diversity of opinion has existed as to the origin of cirrhosis of the kidney. The Germans have, almost without exception, since the appearance of Frerichs' work in 1851, insisted that renal cirrhosis was always and necessarily a sequel of chronic parenchymatous nephritis; that the small granular kidney was produced by contraction from the large white kidney. English authors have been just as positive in maintaining the origin of this condition independently of acute and chronic parenchymatous nephritis, asserting that the disease is often from the first a primary affection. It is now established beyond all question that there arises as a primary affection a clinical picture presenting precisely the same features as may be exhibited by a case of prolonged chronic nephritis; and that in both conditions the kidneys are found post-mortem to be much reduced in size and to contain an excessive development of connective tissue. In short, the two affections are both clinically and anatomically one; that is, the symptoms and post-mortem appearances may occur either with or without a pre-existing acute and chronic nephritis.

It is therefore established that the three distinct clinical pictures, each associated with a definite and peculiar abnormality of the kidney—acute nephritis, chronic nephritis, and renal cirrhosis—are frequently successive stages of the same affection. The two later stages are distinguished as chronic parenchymatous and chronic interstitial nephritis; these terms imply, not that the affection is confined to the connective tissue in the one case nor to the epithelium in the other, but simply that the preponderance of abnormality is found post-mortem in the epithelium and in the connective tissue respectively.

Since both chronic parenchymatous and interstitial nephritis may occur as later stages of an acute nephritis in one individual, it is evident that there can be no sharp line of demarcation between them; for a gradual transition from one to the other occurs in both clinical symptoms and anatomical appearances. In many cases, therefore, there are found the symptoms belonging to both types, and a large number of diseased kidneys exhibit anatomical changes, gross and microscopical, characteristic of both; these are the transitional forms between the recognized types.

The clinical symptoms characteristic of the respective forms of chronic nephritis are not directly dependent upon the condition of the kidney; hence the post-mortem appearances of the kidney cannot be predicted with certainty from the symptoms; a lack of correspondence between the two is especially frequent in those cases in which the renal cirrhosis is a sequence of chronic parenchymatous nephritis. General dropsy and pronounced albuminuria are usually, though not always, associated with the large white kidney; polyuria with a small percentage of albumen and freedom from dropsy, though usually significant of the small granular kidney, are also found in cases where the autopsy discloses the large white kidney.

Acute Nephritis.

Etiology.—This may arise as the extension of an inflammation from lower portions of the urinary tract or from the tissue surrounding the kidney; yet such propagation usually produces a suppurative or chronic and not an acute nephritis.

Nearly all cases of acute renal inflammation are of hæmatogenous origin. The kidneys are pre-eminently excretory organs, eliminating the natural products of tissue metamorphosis as well as extraneous constituents of the blood. This elimination is accomplished largely through the vital activity of the cells lining the convoluted tubules, and partly, perhaps, through the instrumentality of the cells covering the glomeruli. Now it is well established experimentally that acute nephritis arises from the elimination of certain foreign substances, such as cantharides; and that the inflammation in this case begins and may even be confined to the cells concerned in this work of elimination. Moreover, it is a familiar clinical observation that acute nephritis is a regular feature in those infectious diseases in which a foreign element of infection has been demonstrated; I refer particularly to the septic diseases—septicæmia, pyæmia, erysipelas and diphtheria—and to anthrax (malignant pustule). In these diseases it is demonstrated that the morbid element of infection is a microscopic organism; and it is equally well established that these organisms are found in the inflamed kidney, where they constitute foci of inflammation. In other infectious diseases in which acute nephritis is a frequent occurrence, the infectious material has not yet been localized; hence the assumption that the renal inflammation is originated by the effort of the excretory cells to eliminate the morbid material, is an inference supported by analogy.

As already stated, it has been amply demonstrated upon animals that acute nephritis is originated by the excretion of certain substances used as remedies, especially cantharides. Many clinical observations prove that the same result is produced by the elimination of the same drugs in the human subject; among the most conclusive of these are the observations of Lassar.[1] After demonstrating the renal irritation induced by the inunction of petroleum, croton oil, cantharides, etc., in rabbits, Lassar experimented with a human subject. A healthy man, twenty-four years of age, was rubbed with Peruvian balsam for the relief of scabies. In a few days he exhibited general dropsy, which involved the face as well as the extremities. The urine was red, scanty, specific gravity 1.025; it contained albumen, blood, and lymph-corpuscles, fatty epithelial cells from the kidney, hyaline, granular, epithelial, and blood casts; in short, there was an acute nephritis. The inunctions of balsam were discontinued, after which the symptoms gradually subsided and the urine became perfectly normal. To determine whether or not the nephritis was a consequence of the inunctions or merely a coincidence, Lassar renewed the former condition by rubbing 20 grammes of Peruvian balsam into the skin on each of three consecutive days. After the second inunction a slight albuminuria appeared while the daily urine fell from 3,600 to 1,700 c.c. After the third inunction there was decided albuminuria, the quantity of urine sinking to 1,050 c.c.; the sediment contained blood-corpuscles, epithelial and blood casts. On the following day there was some œdema. The urine amounted to 700 c.c., specific gravity 1.025, very albuminous; blood and epithelial casts in great

[1] Virchow's Archiv, Bd. 77, and Charité-annalen, 1881.

profusion. On the next day there was a general exaggeration of the symptoms. Under treatment (uva ursi and warm baths) the urine became normal in three days. Several days after the restoration of health the skin was again rubbed with Peruvian balsam ; on the following day there was decided albuminuria, but the experiment was abandoned as satisfactorily demonstrating the dependence of acute nephritis in the human subject upon inunctions with balsam.

The *causes* of acute nephritis are chiefly as follows :

1. *The infectious diseases*, foremost among which, as to frequency, is scarlet fever. The septic diseases, including ulcerous endocarditis, erysipelas and diphtheria ; typhus, typhoid, yellow, and malarial fevers, pneumonia, small-pox, and acute rheumatism are some of the morbid conditions with which acute nephritis may be expected.

Scarlatinal nephritis begins usually about the end of the third week, but may be delayed until the fifth or even the sixth week. In very many instances the little patient is apparently convalescent before the first symptoms of the renal affection are manifested ; and the serious, often fatal illness which then ensues is falsely attributed by the laity and by some physicians to neglect in protecting a child from "taking cold." The fact seems to be that exposure to cold has but little if any influence in originating nephritis after scarlet fever ; the inflammation is evidently produced by the specific infectious material. Yet while no especial care is necessary in preventing the child from enjoying fresh air in a proper way, it is absolutely imperative that the physician shall keep a strict supervision over the general condition and especially the urine of the patient until the sixth week has expired. This is necessary not only in the severe and dangerous cases of scarlet fever, but also in the mild ones ; indeed, nephritis is not uncommon in those instances in which scarlet fever is manifested quite indistinctly by soreness of the throat and perhaps an indefinite rash with slight fever—the so-called abortive form—or even when these symptoms have been scarcely noticed ; for in certain epidemics the nephritis may be the only observed manifestation of scarlatina.

There is, unfortunately, nothing in the history of scarlet fever upon which we may predict the probability of renal complication ; it occurs in many mild cases and fails to appear in certain severe instances ; the general character of an epidemic may furnish a clue, for in some renal inflammation is an almost constant feature, while in others it is a rarity. The condition of the cervical glands should be carefully noted ; for the observations of Wagner and Leichtenstern have shown that nephritis is an especially frequent complication when these glands are much swollen, and that the beginning of nephritis during convalescence is often accompanied with a second enlargement of these glands.

In most cases of scarlet fever albumen can be discovered during the first or early in the second week ; this febrile albuminuria must be distinguished from the albuminuria of nephritis, which rarely occurs before the third week. It may be, indeed, impossible to draw a sharp line of demarcation between the two conditions, unless a daily microscopical examination of the sediment be made ; for the onset of renal inflammation may be very insidious and unaccompanied with chills, dropsy, increased excretion of albumen, or other prominent symptom.

2. *Inflammation*, especially when of septic origin or accompanied with suppuration, is frequently followed by acute nephritis. Various surgical affections and operations, chronic and suppurating diseases of the skin, puerperal fever, and extensive burns, are examples. During the existence

of such conditions, frequent examinations of the urine should be made. Inflammation of the heart and its valves, of the lungs and pleura, are occasionally, though less frequently, complicated with acute nephritis.

3. *The introduction into the system of certain substances excreted by the kidneys.* Foremost among these as to the degree of irritation is cantharides, the external application of which is sufficient to induce this result; but copaiba, though less irritating, is probably more frequently responsible for acute nephritis, because it is given so extensively in the treatment of gonorrhœa. Turpentine, cubebs, squills, salicylic acid, mercury, phosphorus, arsenic, the chlorate and even the nitrate of potassium are credited with the same ability, when taken to excess or by peculiarly susceptible individuals; at any rate, the administration of these drugs should be carefully avoided during any irritation or inflammation of the kidney. The list of medicines might be indefinitely extended, since individual cases of acute nephritis from numerous drugs have been reported. Possibly alcohol has induced it, as asserted by Goodfellow; Penzoldt produced fatal nephritis in dogs by administering ethyl and amyl alcohol.

Various poisonous substances produced within the body are also capable of exciting acute renal inflammation; this has been demonstrated of the biliary acids (Nothnagel, Leyden).

Various substances commonly employed as topical applications may cause renal irritation and inflammation; among these are carbolic acid, iodoform, petroleum, mustard, pyrogallic and chrysophanic acids, naphthol; Lassar observed a fatal case of acute nephritis following inunctions with petroleum in the treatment of scabies.

It is certain that the effect of these drugs upon the kidney depends largely upon individual disposition; when employing them, the physician should not fail to detect, by examination of the urine, the possible effects upon the kidney.

4. The disturbance of the circulation resulting from "*taking cold*" is undoubtedly productive of acute nephritis, though often utilized as an etiological scapegoat where other causes are responsible. The relation between cause and effect has not yet been satisfactorily explained; yet the fact has been demonstrated. Müller showed that cooling of the skin causes arterial hyperæmia in the dog; Lassar induced genuine acute nephritis in rabbits by suddenly immersing the animals, after cutting off the hair, in ice-water; hæmaturia can be induced in some individuals by simple immersion of the feet in cold water. The renal irritation is produced by a sudden change of temperature of the skin rather than by prolonged exposure to uniform cold.

Simple mechanical irritation of the skin, such as the scratching in cases of scabies and prurigo, seem sufficient to induce at least renal irritation; Wolkenstein produced albuminuria in animals by pencilling with the Faradic brush.

Pregnancy constitutes either a cause or at least a predisposing influence to acute nephritis; the arrest or termination of gestation is usually followed by restoration of the normal renal function.

The existence of a chronic nephritis renders the individual especially susceptible to an attack of acute renal inflammation. In some few cases acute nephritis must be referred to injury, such as a blow, in the region of the kidney; in other instances it is due to the formation of concretions of uric acid and urates in the renal tubules. Several constitutional diseases, especially syphilis, consumption, and malaria, seem to predispose to renal inflammation; it is observed also quite frequently in various

chronic diseases of the skin, eczema, psoriasis, and pemphigus; it is a frequent complication of extensive burns, and is a regular feature of the acute septic diseases.

In some cases no probable cause nor predisposing influence for an existing acute nephritis has been discovered. In some of these an invasion of the kidney by bacteria appears to be responsible, as in the two cases of acute nephritis and uræmia observed and related by Litten, to which reference has already been made.

Acute nephritis occurs with far greater frequency in certain climates than in others; it seems to be especially common on the sea-coast and in regions where the climate is variable, exhibiting sudden changes of temperature and moisture. In very hot as well as in very cold regions the disease is practically unknown except in connection with infectious and toxic agents.

The frequent sequence of acute nephritis upon scarlet fever accounts for the fact that it is so often observed in childhood.

Morbid Anatomy.—The gross and microscopical appearances of the kidney vary according to the duration of the disease as well as with the cause. At an early stage the kidney is enormously enlarged, even to twice its normal size; the capsule is smooth and transparent and easily separated from the organ. Upon section a serous fluid mixed with blood escapes, showing œdema as well as congestion of the kidney; the Malpighian tufts appear as prominent dark red points, while the cortex of the kidney exhibits the purple color of intense congestion. At different points, small hemorrhages are observed, usually not larger than a pin's head and located chiefly in the cortex. At a later stage the color of the cut surface is much lighter, approaching a yellow or gray; the size of the organ, while greater than normal, is less than in the former case. Here and there are seen dark red spots, indicating the still congested vessels.

Upon microscopic examination there is at first evident only intense congestion and cloudy swelling of the renal epithelium. Capillary hemorrhages are numerous, especially in the capsules of the glomeruli and in the straight tubules.

At a later period the epithelial cells, especially of the convoluted tubules, are found in a state of rapid proliferation, the products of the catarrh sometimes filling the lumen and distending the tubule beyond its normal calibre. Many of the epithelial cells exhibit pronounced fatty degeneration.

In *acute nephritis following an infectious disease* a similar catarrh is observed in the epithelium of the capsules; indeed, the affection is so much more pronounced here than in the rest of the kidney, that it has been termed *glomerulo-nephritis* or *capsulitis;* the frequency of this occurrence after scarlet fever has also given rise to the designation scarlatinal nephritis. The capsules contain masses of cells which are themselves sufficient to compress the glomeruli and thus interfere seriously with the circulation through them; there is found in addition, as Friedländer has recently shown, swelling and fatty degeneration of the capillary walls, which further interfere with the passage of the blood. These anatomical facts explain the familiar clinical observation that the diminished excretion of urine which constitutes a serious feature in every acute nephritis is especially formidable in the disease after scarlet fever, and that there is under these circumstances an especial necessity for securing the excretion of water from the glomeruli; indeed, this filling up of the capsules with cells and nuclei constitutes almost the only abnormality observed in some fatal cases of scarlatinal nephritis.

In many cases of acute nephritis the kidneys alone present abnormal appearances, though the body generally is as a rule dropsical. The dropsical fluid is found in the subcutaneous connective tissue generally as well as in the various serous sacs and frequently in the alveoli of the lungs. In occasional cases the mucous membrane of the larynx exhibits a similar dropsical swelling. It has lately been demonstrated, anatomically as well as clinically, that acute dilatation and even hypertrophy of the heart is not infrequent in the course of acute nephritis, especially during the infectious diseases.

The urinary channel, the kidney, pelvis, ureter, and even the bladder are occasionally found in a state of inflammation.

Acute inflammation may, as already stated, arise as a complication in the course of chronic nephritis; in this case the anatomical appearances in the kidney as well as elsewhere present the changes characteristic of both affections.

The acute nephritis which arises in the course of septic diseases is often marked by the appearance of miliary abscesses, originating in emboli of bacteria.

Symptoms and Course.—The disease may begin quite abruptly or very insidiously; in children especially suspicion is often first aroused by the occurrence of œdema, manifested either as dropsy of the feet or as puffiness of the eyelids and broadening of the bridge of the nose. When it occurs as a sequel to scarlet fever, acute nephritis is sometimes unsuspected until the initial symptoms of uræmia are manifested. I was recently summoned in haste to see a child in convulsions. The little patient had been apparently well in the morning, somewhat drowsy in the afternoon, had been put to bed at eight o'clock, and at midnight was found in convulsions. I ascertained that the child had about four weeks previously suffered from a mild attack of scarlet fever, which had confined him to the bed only a few days; the physician in attendance had discontinued his visits some time previously. A little urine which I was enabled to obtain was very albuminous and contained numerous blood-corpuscles and epithelial casts. Death occurred before daylight from uræmia. The child had been regarded for a week as convalescent, and no suspicion of the existing renal inflammation had been entertained.

In the greater number of cases, especially those occurring in adults as the result of exposure to cold, acute nephritis is ushered in with one or more severe chills, followed by decided fever; the latter may be transient, the disease running its course without any constant elevation of temperature. Nausea and vomiting, loss of appetite, headache, and constipation indicate some constitutional disturbance; the locality of this disturbance is often indicated by pain and tenderness in the loins, though this symptom is by no means constant or essential. An early symptom in some cases is irritability of the bladder; urination is frequent and often painful, a small quantity of bloody urine being voided at each act. This symptom, taken in connection with the appearance of the urine, may, if the œdema be slight and undiscovered, raise a mistaken suspicion of cystitis.

Meanwhile a prominent symptom familiar to the laity usually becomes apparent—dropsy. The swelling is often first observed around the eyes, usually spreading over the entire surface, but sometimes affecting only the face and the genitals. The distribution of the œdema depends somewhat upon the patient's position, being usually most pronounced in the dependent portions of the body. The dropsy may change entirely the facial expression as well as interfere with the movements of the limbs; a peculiarity

often observed is a broadening and flattening of the bridge of the nose, caused by the swelling on either side. The œdema is at first usually subcutaneous, but sooner or later the large serous sacs are also involved, and œdema of the glottis, the lungs, or the brain may close the scene. Dropsy, though usual, is not a constant symptom; moreover, it may exist during scarlatina without nephritis (Quincke).

The most characteristic symptoms are found in the condition of the urine. This is always scanty, turbid, and red, brown, or smoky in appearance from the admixture of blood; the smoky tint is seen in very acid urine. The quantity is always diminished, sometimes to 200 or 300 c.c. per day; even complete anuria may occur. In nearly every case albumen is present in appreciable amount, often from one-half to two per cent.; when coagulated by heat and allowed to settle, the albumen may occupy from one-fourth to one-half of the test-tube. While this method by deposit of the coagulated albumen may be a convenient way for daily comparison, it should be remembered that it does not afford a means for estimating even approximately the actual percentage of albumen in the urine; this quantity is rarely more than two per cent.

It is clinically important to note that in some cases of acute nephritis, especially those following scarlet fever, the temporary absence of albumen is not rare; hence a failure to detect albuminuria does not necessarily prove the absence of nephritis. In acute renal inflammation from other causes it has also been occasionally observed that the urine, although generally albuminous, may for days at a time be free from albumen.

The *sediment* furnishes important information, and the microscopic examination of it should never be omitted; for epithelial casts and renal epithelium are present even when no albumen can be detected. The sediment is usually copious, and consists largely of the acid urates; the important elements present are, however, blood-corpuscles, leucocytes, renal epithelium, and casts (Fig. 10).

Blood-corpuscles are rarely absent, even though the gross appearance of the urine may not indicate their presence; they may constitute the bulk of the sediment. In some cases they are doubtless overlooked even upon microscopic examination, since they are often devoid of the usual coloring matter and show many variations in size and shape; thus they frequently exhibit the crenated form and are found in various sizes from the usual diameter to mere points; these are the so-called "microcytes." In some few cases the red corpuscles have been seen to execute amœboid movements; they are often seen adhering to hyaline or epithelial casts.

The *tube-casts* observed vary much in quantity and variety. If the urine contain considerable blood, aggregations of blood-corpuscles in the shape of casts are usually seen. In some cases there is an abundance of epithelial casts, while in others, especially those which follow scarlet fever, but few such cylinders are seen, the greater number being hyaline and granular. The hyaline casts are often provided with oil-drops and granules, urates, crystals of calcium oxalate, and in a few cases crystals of hæmatoidin. Sometimes they exhibit a tint derived evidently from the coloring matter of the blood, while at other times their appearance suggests that of the casts found in amyloid degeneration of the kidney.

The preponderance of one or another element of renal origin in the sediment is sometimes significant as to the course of the disease. Thus epithelial cells and casts in abundance indicate an especial implication of the renal epithelium, a condition which may be overlooked, since the quantity of urine excreted may be but little diminished; on the other

hand, but few renal cells or epithelial casts may be observed in those cases in which the glomeruli suffer especially, although the amount of urine excreted is much diminished. In these cases of glomerulo-nephritis there is often present an especially large amount of blood. As already stated, epithelial casts are sometimes found without albuminuria; they are frequently observed at an earlier period than the albuminuria, and sometimes persist for a considerable time after the albumen has disappeared from the urine.

The number of *leucocytes* observed varies much in different cases; in some instances their abundance indicates a catarrhal condition of the renal epithelium. They are doubtless often mistaken even by experienced observers for renal epithelial cells.

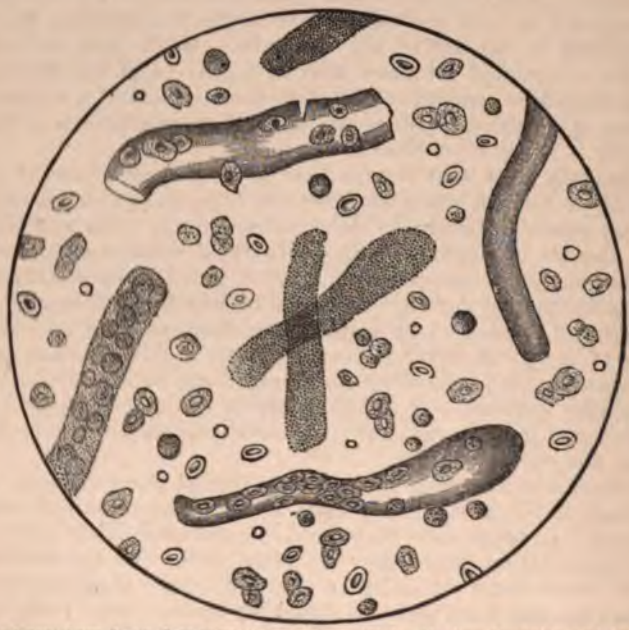

FIG. 10.—Sediment from Acute Scarlatinal Nephritis, containing Hyaline, Granular, and Amyloid Casts, Renal Epithelium, Blood-corpuscles and Leucocytes.

The sediment always contains a considerable amount of granular matter, which consists largely of urates. There is also an abundance of fatty granules furnished by the débris of epithelial cells.

In some cases casts composed entirely of granules of uniform size and glistening appearance are observed; these granules exhibit with the aniline coloring matters the reaction characteristic of micrococci. Such casts are seen quite often in cases of acute nephritis from septic infection—pyæmia, puerperal fever, etc.; they are also seen in cases of nephritis arising by extension of the inflammation from the pelvis to the tubules; and in a few cases such casts have been found in cases of nephritis of unknown origin.

In some cases of acute nephritis the patient experiences a constant desire to micturate, though but a few drops of urine are expelled at each act. This symptom is not to be taken as evidence of cystitis, unless supported by other indications. If the renal inflammation have been caused by cantharides, copaiba, or turpentine, or if these remedies have been employed

internally or externally in the course of the affection, strangury may occur; in cases of poisoning by cantharides extensive fibrinous clots have formed in the urine, rendering the use of the catheter necessary for the evacuation of the bladder.

In the last few years it has been demonstrated that an appreciable dilatation of the heart is a frequent phenomenon; it is an almost constant and often an early symptom of scarlatinal nephritis in children. If pronounced it can be detected by physical examination; but even when unrecognizable, it may cause severe asthma and cyanosis. This dilatation is observed especially in the left heart, and so suddenly that it may be mistaken for effusion into the pericardium; it may be so severe as to constitute the immediate cause of death. Dilatation of the heart may be suspected if blood murmurs are distinctly audible; these disappear when compensatory hypertrophy is established, a process which may be accomplished in a surprisingly short time. Dilatation and hypertrophy are the result of an increased blood-pressure, which is indicated by the unusual tension of the pulse. This increased tension is constant in severe uncomplicated cases, and is accompanied by a retardation of the heart-beats (Riegel).

In favorable cases no implication of other organs is observed. The symptoms already described continue with more or less constancy for one or two weeks. It is noticeable that the condition of the urine may vary extremely during this time; not infrequently the blood and even the albumen disappear, so that the urine shows no abnormality except upon microscopic examination. This return of the normal appearance sometimes deceives the physician into the hope that the renal inflammation has subsided. Such hopes are, however, usually blighted in a day or two by a return of the blood and albumen in perhaps even larger quantity than before. In many cases there is no permanent improvement in the condition of the urine for two, three, or even four months; periods of improvement alternate with exacerbations. A diminution in the quantity of urine is usually accompanied with an increase in the œdema.

Sooner or later there occurs a permanent improvement (in non-fatal cases) which is marked by a decided increase in the excretion of the urine; the amount excreted may indeed much exceed the normal quantity, even three- or fourfold. The excretion is especially copious when the œdema has been extensive. The emaciation which has occurred (though perhaps concealed by the anasarca) now disappears, sometimes to be succeeded by an unusual development of adipose tissue. The blood usually disappears from the urine, though the albumen may be detected for months after the patient is apparently convalescent; casts too, even of the epithelial variety, may persist even longer than the albuminuria.

In a certain number of cases, constituting only a small percentage, the kidneys never resume their normal condition. The patient makes an apparent recovery and enjoys good health for months; perhaps the albumen disappears from the urine. But after the lapse of some months the diminished excretion of urine, its turbidity and high specific gravity, the marked albuminuria, œdema, etc., show that the inflammation of the kidney has become chronic.

Complications.—The œdema sometimes occasions serious and even fatal complications by accumulation in the pulmonary vesicles, the pericardial, pleural, meningeal, or peritoneal sacs. In occasional cases the mucous membranes become œdematous, and a fatal termination may result from sudden œdema of the glottis. These serous transudations may occur in the course of a few hours, and can scarcely be distinguished from the prod-

ucts of inflammation; it must be remembered that sudden dilatation of the heart is often developed, simulating effusion into the pericardial cavity. In some few cases these serous effusions become purulent, usually in cases of nephritis following infection; the use of the trocar or aspirator for removing the liquid is unsafe. Œdema of the subcutaneous tissue may cause localized sloughing of the skin; the swelling of the scrotum is sometimes so great as to impede the exit of urine, and require the use of the catheter.

Gastric and intestinal irritation and catarrh are frequent symptoms in the course of nephritis, especially when it follows scarlet fever; these may doubtless be produced by simple œdema of the mucous membrane, though it is possible that an inflammatory action also occurs; loss of appetite, obstinate vomiting, and diarrhœa result from this irritation of the alimentary canal. Inflammation of the serous membranes and of the lungs is an occasional complication. Loss of vision may result from simple anæmia of the retina, or may be due to an actual inflammation of this structure.

The most serious as well as the most insidious danger to be apprehended in the course of an acute nephritis is, however, *uræmia*. The probability of such serious retention of the urinary constituents increases of course with the diminution in the quantity and specific gravity of the urine; yet uræmia may occur in cases where the comparatively free excretion of urine has allayed any fears of this complication, and where no dropsy exists.

A suspicion of uræmic poisoning should be entertained if there be continuous or violent headache (a frequent sign in the nephritis of pregnancy), sudden impairment of sight or hearing, repeated vomiting, somnolence or drowsiness, asthmatic attacks, watery diarrhœa, intense itching of the skin, spasms of the muscles; profuse epistaxis and irritability of temper are also frequent premonitory signs of the retention in the blood of a dangerous amount of urinary constituents. Yet the attack may occur without the exhibition of these preliminary symptoms; children especially are known suddenly to fall into coma and convulsions even when apparently convalescent from scarlet fever; since, moreover, the symptoms of nephritis after scarlatina are often obscure, it is incumbent upon the physician to examine the urine at intervals for two or three weeks after such an attack, even though the child be apparently free from disease.

The *duration* of scarlatinal nephritis is variable; death may occur in a few days or after the lapse of many weeks. Recovery—the termination in about two-thirds of the cases—is seldom attained in less than a month, and may be postponed for several months, perhaps by relapses into the acute stage. In some instances the kidney never recovers its functions completely; after an interval of apparent health, lasting several months or a year or two, the symptoms of chronic nephritis become apparent. The persistence of albuminuria or casts or both for some weeks after the disappearance of other symptoms is not unusual in cases which ultimately recover entirely.

The nephritis of diphtheria is developed during the intensity of the disease and is more frequent in severe cases. Much albumen and blood are contained in the urine; yet recovery from the renal complication is the rule if the patient survive the primary disease; Leyden has seen cases ultimately recover after lasting more than a year. During the course of typhoid fever nephritis is most frequent in the second week; its symptoms may be so prominent as to distract attention from the original affection, especially if the history be incomplete; for this reason French

authors describe it as a "renal form" of typhoid. Uræmia is not uncommon, and the prognosis is in general grave. The renal inflammation is often accompanied with catarrh of the urinary channels; the number of leucocytes may thereby become so great as to simulate pus.

Acute nephritis developed during the course of croupous pneumonia appears on the fourth or fifth day and subsides in eight or ten days; it is not a serious complication. The acute renal inflammation which complicates inflammatory rheumatism seems to appear only in those cases in which the endocardium is involved in the inflammation; this nephritis frequently becomes chronic (Leyden).

Syphilis is considered responsible for many cases of chronic but for few of acute renal inflammation; Fürbringer has repeatedly observed mild desquamative nephritis during secondary syphilis. That malaria produces acute as well as chronic nephritis must be admitted; according to the recent observations of Kelsch and Kiener, it causes in Algiers almost as many cases as does scarlet fever. This form of acute nephritis frequently becomes chronic.

Diagnosis.—A typical case of acute nephritis can hardly escape recognition or be confounded with other affections; even when the initial chill, vomiting, etc., are absent, the dropsy and the scanty, bloody, and albuminous urine render the diagnosis easy. Yet not all cases are typical, and as a result acute inflammation of the kidney is often overlooked or discovered only when uræmic symptoms become prominent. In acute nephritis following scarlet fever especially the dropsy may be inconsiderable until the affection is well established. In not a few cases albumen is absent from the urine temporarily; and in the absence of these two prominent symptoms—œdema and albuminuria—the physician who does not use the microscope is not in a position to recognize the renal inflammation.

It has been asserted by Mahomed that there is a pre-albuminuric stage of acute nephritis, indicated by the high arterial tension and the escape of hæmoglobin from the kidneys; and that if this stage be recognized, the development of renal inflammation may be averted by exciting the skin and bowels to brisk action. The hæmoglobin can be detected, if no albumen be present, by the following test: To two or three drops of urine in a small test-tube, one drop of the tincture of guaiac and four or five drops of ozonized ether are added; the tube is shaken; the ether collects then at the top of the liquid. If hæmoglobin be present this upper layer of ether exhibits a blue color, while the urine below is colorless. This test may be of value if the urine be frequently examined during and after an attack of scarlet fever. The possibility of previous scarlatina, even without angina or exanthem, should be made the subject of inquiry, particularly during an epidemic of the disease.

A not infrequent error in diagnosis is the assumption of nephritis in cases where simple congestion of the kidney alone exists. If this be the result of valvular heart disease, the two prominent symptoms—œdema and albuminuria—are usually present, and a considerable number of casts is observed in the sediment. The distinction can, however, be made without difficulty in most cases; the existence of the cardiac lesion and the evidences of venous congestion elsewhere together with the gradual development of the symptoms indicate the dependence of the renal disturbance upon the heart; moreover, the dropsy of acute nephritis affects the face as soon as the feet, while that of cardiac disease extends from the feet upward by continuity. The percentage of albumen is usually greater in nephritis than in renal congestion, and blood-corpuscles are more numer-

ous in the sediment. The microscopic examination of the sediment usually affords conclusive evidence as to the nature of the renal complaint; while congestion of the kidney produces numerous hyaline casts, inflammation furnishes epithelial and granular casts in abundance.

Hemorrhage from the kidney following embolism and infarction may also suggest the existence of acute nephritis. The distinction is sometimes rendered less easy by the similarity in history between the two; thus embolism may begin with decided pain in the loins, chill, fever, and vomiting. If this occur during the course of venous congestion of the kidney, the similarity to acute nephritis is even greater. It will be found, however, that the sediment does not contain the casts characteristic of renal inflammation, and that the percentage of albumen is not greater than can be furnished by the blood present.

Another difficulty in diagnosis arises from the possibility that a present acute nephritis may be an exacerbation of a previously existing chronic nephritis; for this affection may have lasted for some time unsuspected, and it predisposes to attacks of acute renal inflammation. If there be no previous history pointing to the existence of acute nephritis its recognition may be impossible until the most pronounced symptoms of the acute affection have subsided. Finally, care must be taken to discriminate, during the course of a febrile affection, between actual nephritis and febrile albuminuria; in making this distinction the microscope is indispensable.

Prognosis.—In many cases the patient recovers perfect health; yet this fact does not justify a habit of favorable prognosis, since even mild cases may develop unexpected and serious complications. Moreover, a chronic nephritis may be a sequel of the acute inflammation. A favorable prognosis must therefore always be made with caution and reservation, and can be sustained only by careful daily examination of the urine as well as of the patient's general condition. During convalescence relapses are frequent and may be occasioned by slight provocation, such as exposure to cold; after scarlet fever children require especial care to prevent this accident.

Treatment.—The treatment of a patient suffering from acute nephritis is determined largely by the etiology of the affection, as well as by the condition of the kidneys as indicated in the urine. In some cases it is the result of malarial or syphilitic infection, or it may have been produced by the use of medicines. Thus Bartels narrates a case in which the appearance of the urine led him to suspect and finally discover that the patient was using cantharides; the discontinuance of this application was followed by immediate return of the urine to its normal condition. In every case, therefore, inquiry should be made as to the possibility of these specific infections, as well as concerning the diet and the drugs which the patient may have used internally or externally; such inquiry may elicit information that shall lead to special therapeutical measures—the iodide in a syphilitic individual, quinine in malarial conditions, etc. If the patient be a child or youth, careful inquiry will often elicit a history of recent scarlatina, perhaps unrecognized and manifested only by soreness of the throat or a doubtful rash.

Certain general measures—rest, quiet, and warmth—are applicable in all cases; the inflamed renal tissue as well as the secondarily disturbed digestive tract profit by an unirritating diet; this should consist chiefly or exclusively of milk; if the patient tire of this alone, eggs, broths, and a little meat are permissible, notwithstanding the excess of nitrogenous material contained therein. Rest in bed is an absolute necessity, not only for the comfort of the patient, but also for the avoidance of certain attend-

ant dangers; thus the acute dilatation of the heart, the transudations in various serous cavities, and the arrest of the cutaneous excretion, are less apt to occur and to entail serious consequences if the patient remain warmly covered in bed.

There are so far as known no means for arresting the local inflammation in the kidney; like most acute inflammations, nephritis appears to be a self-limited disease. The efforts of the physician are therefore directed first to securing the vicarious excretion of the constituents of the urine, and second to the removal of the products of inflammation from the kidneys.

The excretion of the urinary constituents can be accomplished in large part by the skin and the bowels, which are supplementary to the kidneys even in health. By arousing them to increased activity, the urea and salts which the inflamed kidneys fail in large part to excrete can be eliminated, and their deleterious influence upon the system generally prevented.

The cutaneous excretion is readily increased by the use of warm baths; the patient is placed every day and allowed to remain for twenty to forty minutes in a bath maintained at a temperature of 38° to 40° C, is then rolled in blankets and allowed to perspire for one or two hours. Although one or more pounds of water escape from the skin during this time, the urine is usually increased in amount, presumably from the absorption into the circulation of the liquid and urea contained in the serous and subcutaneous spaces. These warm baths may not be employed in every case; they frequently cause faintness, mental anxiety, and difficulty of breathing, or even sudden collapse; uræmic attacks have been brought on by them, apparently from the sudden return into the circulation of the urea and salts contained in the œdematous fluid. If the patient exhibit in advance any dyspnœa or failure of the heart, these baths should not be employed; in their stead the cold pack—which is free from the depressing influences of the bath—should be used. The patient is wrapped in a wet sheet, then covered with several blankets until free perspiration has been induced. If this fail, advantage may be derived from Ziemssen's method of wrapping the patient in hot cloths.

In urgent cases in which the skin cannot be aroused to action by such measures, pilocarpine must be administered; one-twelfth to one-eighth of a grain of the nitrate or one-fifth of a grain of the hydrochlorate may be injected subcutaneously. This remedy may induce not only salivation and vomiting, but even dangerous depression of the heart and œdema of the lungs; these ill effects can be to some extent averted by administering one or two teaspoonfuls of brandy half an hour before the injection. Yet the remedy must be used with extreme caution whenever the condition of the heart or lungs is unsatisfactory; it is noteworthy that the diaphoretic effect of pilocarpine is less certain when the kidneys are inflamed than in health.

The bowels should be stimulated to free excretion. This can be accomplished by the administration of small doses of podophyllin (one-twelfth grain); more decided effect is produced by the compound jalap powder, ten or twenty grains of which may be administered at intervals of four hours until free purgation is induced. If the case be urgent, and symptoms of uræmia threaten, the most active cathartics—elaterium and croton oil—are required. Mercury should be avoided.

A most important part of the treatment is addressed to the kidney itself. It has often been argued that the inflamed kidney, like any other inflamed tissue, should be afforded perfect repose; to this end it has been

advised that excess of liquids and all diuretics should be avoided. This plan is excellent in principle, except in so far as it ignores the fact that one of the chief dangers to the integrity of the kidney, as well as to the life of the patient, lies in the obstruction of the urinary tubules and capsules of the glomeruli by the accumulation of epithelial cells and casts. Oliguria is a pronounced symptom, especially in the acute nephritis following scarlet fever and other infectious diseases; and the danger of uræmia increases, generally speaking, as the amount of urine diminishes. The reason for this oliguria is found in the accumulation of cells and nuclei in the tubules, but especially in the capsules of the tufts; in the latter locality the catarrh and accumulation of cells is often so great as to compress and practically obliterate the glomeruli, rendering them impermeable to blood. It is evident, therefore, that an effort must be made to keep the blood circulating through the glomeruli and to secure a free transudation of water into the capsules so as to remove the products of the catarrh; the necessity for this free excretion of water is especially great in the acute nephritis of the infectious diseases.

A consideration of these facts leads to the adoption of just that line of treatment of the kidney which is empirically found in practice to be most beneficial: the object should be to increase the arterial pressure in the kidney and to supply the blood with an abundance of water. At the same time it is desirable and quite practicable to refrain from stimulating the secreting cells of the convoluted tubules. To administer turpentine, juniper, or squills would be disastrous, since these stimulate the already inflamed secreting structures. The only diuretics whose employment is both unobjectionable and imperative are *digitalis* and *water*. The former, by its stimulation of the heart and of the renal arterioles, increases the arterial pressure in the renal vessels, whereby an increased transudation of water occurs and the glomeruli are kept pervious; both of these results are furthered by the presence of water in large quantity in the blood.

Digitalis should be administered in more than the usual quantity. If the tincture must be used (it is not always reliable) from thirty to forty minims should be given in the course of every four hours, until the quantity of urine is decidedly increased; this amount is too large to be borne by the already irritable stomach, unless divided into doses of five or ten minims each. The pulse should be carefully observed and a decided decrease of its frequency should be the signal for diminishing the quantity of the drug. If practicable, the infusion of digitalis should be used rather than the tincture; two to four drachms may be given to an adult and a correspondingly smaller dose to a child.

The patient should drink an abundance of water; and in order to secure his compliance with this direction, it should be prescribed not as vulgar drinking-water, but as an alkaline mineral water, or the "cream of tartar lemonade," made by dissolving a sufficient quantity of bitartrate of potassium in hot water, pouring off the clear solution when cold, and adding slices of lemon and sugar to the taste. It is, however, desirable to avoid the administration of potassium salts, since the recent investigations of Fleischer, D'Espine, and others indicate that the accumulation of these salts constitutes an important factor in the production of uræmia. It is therefore better to substitute the bicarbonate, acetate, and tartrate of sodium for the more popular potassium salts as diuretics in the treatment of nephritis, acute or chronic. These alkaline solutions are beneficial both in increasing the excretion of water and in dissolving the inflammatory products with which the tubules are encumbered (Gerhardt).

It was formerly customary to apply cups or leeches over the region of the kidneys ; it is probable that these measures, employed at the very outset of the affection, are useful ; but the same effect can be produced by the application of poultices or hot fomentations to the loins. These may also be made the vehicle for the administration of an infusion of digitalis, if the drug be rejected by the stomach and rectum.

The premonitory symptoms of uræmia require a more vigorous employment of the principles already discussed. The intestinal tract should be stimulated by croton-oil or elaterium—one or two drops of the former or a quarter of a grain of the latter being administered by the mouth. The skin should be excited by the subcutaneous injection of one-third of a grain of pilocarpine ; or four ounces of the infusion of jaborandi, made from one drachm of the leaves, should be given by mouth or rectum. In the absence of this agent a hot-air bath or wet-pack must be used. If convulsions have occurred and the patient be plethoric, venesection may be practised. The convulsions can often be controlled by the inhalation of chloroform or by the administration of chloral (twenty to forty grains) by the mouth or rectum. The injection of large doses of morphine—half a grain at once, repeated in two or three hours if necessary, until two grains have been given—has been successfully practised by Loomis and Bartholow.

The choice of measures to be employed in treating uræmia is to be determined largely by the condition of the pulse ; for if there is decided cardiac weakness, shown by a small, rapid, and feeble pulse, hot baths and pilocarpine are dangerous. In this case the physician must rely upon active diuresis, the wet-pack, croton-oil, and cardiac stimulants, especially digitalis and camphor. If, on the other hand, the pulse is strong and full, venesection in adults and cups or leeches to the neck in children, are indicated. A fair substitute for venesection is chloroform narcosis, though ether must be strictly avoided. After the patient awakens somewhat from the uræmic coma, advantage has been derived from the inhalation of oxygen—six to eight litres every three hours (Lagrave).

Violent asthmatic attacks may be relieved by large mustard plasters or dry cupping over the chest ; also by morphine and chloral, if the condition of the heart permit their use.

Pronounced œdema often requires treatment, and can be relieved by free diuresis, diaphoresis, and saline cathartics. It may become necessary to afford a local outlet for the transuded serous fluid ; the practice of making incisions in the skin of the extremities and of the genitals is liable to the objection that it favors the development of gangrene and erysipelas. Probably the best method consists in the insertion of hypodermic needles (which should be nickel-plated) in the skin ; these are held in position by adhesive plaster and connected with narrow rubber tubes which are conducted into basins of carbolized water.

After the subsidence of the acute symptoms, extreme care is necessary to avoid an exacerbation of the renal inflammation. The albuminuria and the casts persist for weeks or even months after the fever and œdema have disappeared ; during this time excessive bodily exertion, imprudent exposure to cold or draughts, or over-indulgence at table may provoke a relapse.

The individual is much debilitated by an attack of acute nephritis ; the disappearance of the acute symptoms and of the gastric irritability should therefore be followed by the administration of tonics. Iron is especially valuable ; quinine and malt liquors should also be prescribed. Wines, brandy, etc., should be allowed but sparingly, because of their irritant effect upon the kidneys.

Various remedies have been recommended for the purpose of reducing the quantity of albumen excreted by the kidneys during convalescence from the acute form as well as in chronic nephritis; among these are fuchsin and the tincture of cantharides. The former has been extensively tried and found to be valueless; as to the latter Bartholow says: "In acute desquamative nephritis, after the subsidence of the acuter symptoms, good results are obtained from cantharides. The local condition in which this remedy is serviceable consists in hyperæmia with loss of vascular tonus." I have seen one case in which the administration of five drops of the tincture three times a day, after the severer symptoms had subsided, was followed on the third day by a decided aggravation of the symptoms, the urine showing a pronounced increase in the amount of blood, albumen, and casts present. In the absence of other discoverable provocation, suspicion attached to the cantharides; the remedy is capable in sufficient quantity of arousing acute nephritis in a previously healthy kidney.

Convallaria, Adonis vernalis, and caffein have thus far failed to furnish the anticipated benefits. Nitro-glycerine, so strongly recommended by Robson and indorsed by Bartholow, is worthy of a trial; one minim of an alcoholic solution—one part to one hundred of alcohol—may be administered three times a day if it produce no unpleasant effects, such as headache, etc. It is understood that this remedy must be handled and administered with great caution.

Chronic Parenchymatous Nephritis.

Etiology.—In the majority of cases chronic nephritis (parenchymatous) arises insidiously as a primary affection; it has usually existed some months before a positive diagnosis is made or even a well-grounded suspicion entertained. The recognition of the etiology is therefore not possible in all cases; but it has been established that the disease appears as the effect of certain causes, among which the following are most prominent:

Syphilis and malaria. The dependence of the disease upon syphilitic infection is shown by the rapidity with which, in many syphilitic individuals, it yields to iodide of potassium and mercurials, remedies which in other persons are quite ineffectual. The especial frequency of the disease in certain malarial districts and its increase during malarial epidemics have been often noticed; it seems probable that a comparatively short sojourn in a malarial region may be sufficient to arouse a chronic nephritis. The tendency of malarial influence to induce nephritis varies in different districts; thus Rosenstein saw the renal complication rarely in northern Holland, while on the eastern shore one-fourth of all the cases of chronic nephritis were in his opinion produced by malaria. During an epidemic observed by Heidenhain nearly every case was followed by nephritis. In Algiers malaria is, according to Kelsch and Kiener, productive of numerous cases of chronic renal inflammation.

Exposure to cold and moisture. Such exposure occurs from living in damp dwellings as well as in moist and changeable climates; the disease is especially frequent upon certain sea-coasts.

Chronic suppuration is sufficient to induce chronic nephritis as well as amyloid degeneration of the kidney; either or both of these affections may therefore be observed in the subject of caries and necrosis of bone, consumption, chronic ulceration of mucous or cutaneous surfaces, etc.

The *abuse of alcoholic drinks* is generally considered responsible for the

occurrence of chronic nephritis. It seems probable, however, that the effect is not immediate and direct, but is brought about by digestive disturbances induced by the alcoholics.

That *chronic poisoning with mercury, arsenic, and lead* can induce chronic inflammation of the kidney is extremely probable.

In a comparatively small number of cases chronic renal inflammation can be definitely traced to an *an acute nephritis.* This prolongation of an acute into a chronic renal inflammation seems to occur with relative frequency after scarlet fever, syphilis, malaria, and exposure to cold.

Habitual overindulgence in nitrogenous food is doubtless responsible for many cases of chronic nephritis as well as of cirrhosis of the kidney. This is an almost universal hygienic error in England and the United States, though it is impossible to determine with accuracy the extent of its influence in producing the disease.

Chronic parenchymatous nephritis is rarely observed in youth, being pre-eminently an affection of adult life; the symptoms usually appear between the twentieth and fiftieth years. In a few cases it has been observed in children afflicted with congenital syphilis; in one reported by Bradley the usual signs of chronic nephritis were developed by a child four months old, the subject of congenital syphilis. Chronic suppuration seems to produce in children the amyloid degeneration rather than chronic inflammation of the kidney. Males are more frequently attacked than females—a fact which is doubtless explained by the differences in the occupations of the sexes.

Morbid Anatomy.—The anatomical appearances vary extremely with the period of the disease. The typical kidney of chronic nephritis is that usually designated by English authors the large white kidney. This is not, however, the only form observed; for this large kidney finally undergoes contraction (if the patient survive long enough) into the small granular kidney; yet the symptoms—which are determined by many other factors than the condition of the kidney—do not necessarily undergo a change corresponding to the alteration in the renal structure; hence all gradations between the large white and the red contracted kidney are found post-mortem in cases which present a more or less perfect clinical picture of chronic parenchymatous nephritis. Wagner, supported by several German pathologists, believes that the large white kidney results as a rule from a combination of chronic nephritis and amyloid degeneration.

The large white kidneys (Wilks) may be from two to three times the normal size and correspondingly increased in weight. The capsule is tense and retracts when the organ is laid open; it is often thickened and white, in certain spots particularly. The kidney itself is of a yellowish color except where the vessels are deeply injected; this injection is confined chiefly to the medullary portion of the organ. The yellow color of the cortex is intensified in spots and stripes corresponding to portions of the tubules and glomeruli around which inflammatory products have accumulated. That the yellow color is due to fatty degeneration is evident upon simple inspection and is demonstrated by the appearance of fat drops upon the knife.

Upon microscopic examination the attention is especially arrested by the pronounced degeneration of the renal epithelium. The epithelial cells, chiefly or even exclusively of the convoluted tubules, exhibit advanced fatty degeneration, manifested not only by the presence of granules and drops of fat, but also by the coalescence of cells which frequently obstruct the lumen of the tubule entirely.

The interstitial connective tissue exhibits less pronounced changes, but is nevertheless in a state of inflammation. This is indicated by the presence of masses of leucocytes, which are found chiefly around the glomeruli and the convoluted tubules. An actual increase in the amount of mature connective tissue is also visible at different places.

The glomeruli, too, present evidences of inflammatory action. Some of the capsules are filled with a granular albuminous or fatty substance by which the tufts themselves are compressed; the epithelial cells are swollen, often proliferating, and frequently exhibit fatty degeneration. The capillary walls of the tufts may also show fatty change and decided swelling; the glomeruli are usually devoid of blood.

At a later stage of the disease the kidney is much decreased in size, being perhaps even smaller than the normal organ. In this condition the degenerated epithelial cells have disappeared, leaving, perhaps, granular masses in the tubules. The tubes themselves are collapsed, even obliterated by adhesion of the opposite sides. Many of the glomeruli exhibit similar changes; the capsules are thickened, the tufts themselves shrunken or even transformed into a homogeneous mass devoid of blood. Sometimes the capsule is filled with a dark granular mass, which presents no similarity to the original structure, but which is decomposed with effervescence upon the addition of nitric acid. This granular mass is the result of calcification consequent upon the previous fatty degeneration.

At this stage the interstitial connective tissue is much increased; the masses of young cells present in the large white kidney have become transformed into streaks of connective tissue which frequently extend to the surface of the cortical portion and produce cicatricial depressions. In consequence of this new formation of connective tissue, the capsule of the kidney is decidedly adherent, its surface uneven and even granular.

The microscopic appearances of these kidneys vary according to the degree of shrinking which has occurred; the appearances characteristic of the large white kidney remain to a greater or less extent.

In the organs other than the kidney various changes are observed: the serous cavities contain fluid and sometimes pus; the lungs frequently exhibit catarrhal pneumonia; the intestine is inflamed and the lower portion perhaps ulcerated; the heart is dilated or hypertrophied.

Symptoms.—In a few cases chronic nephritis is a continuation of an acute inflammation; in these instances the albuminuria and dropsy may persist in slight degree after apparent convalescence from the acute attack, and may become gradually more pronounced with the lapse of time. In other cases an interval of several months or years may elapse between the subsidence of the acute nephritis and the discovery of the chronic form, during which period the patient apparently enjoys perfect health; finally a gradual emaciation and pallor, with general debility and perhaps slight dropsy of the feet, direct attention to the urine, where the cause of the difficulty is revealed.

In the majority of cases chronic nephritis is a primary affection and begins insidiously. At present dropsy and albuminuria are regarded as the first positive symptoms of the affection; but in many, perhaps all, cases the disease has existed for some time before these symptoms are discovered or even discoverable. While a diagnosis of chronic nephritis can scarcely be made until the characteristic features of the urine are observed, yet suspicion of this condition should be aroused by various other symptoms. Thus debility, emaciation, an unusual and persistent pallor, occurring without evident cause, should be regarded as an imperative indication for

the examination of the urine—not once only, but several times at intervals of days—as well as for an inquiry into the history of the patient as to the previous occurrence of acute nephritis, syphilis, malaria, and the other known causes of chronic renal inflammation. The earliest symptoms of chronic nephritis are often such as mislead the physician as well as the patient into a suspicion of disease in other organs; thus it has repeatedly happened that patients have been long treated for anæmia, general debility, etc., without any suspicion of renal disease and without any examination of the urine, until a gradual impairment of vision has led the patient to consult an ophthalmic specialist; the discovery of the so-called albuminuric retinitis has led to an examination of the urine, which was found loaded with albumen. So too a chronic diarrhœa has proved most obstinate and has defied explanation and treatment until the condition of the urine has been discovered; frequent chills have been considered malarial until albuminuria or œdema has been detected. Chronic gastritis, intermittent dyspepsia, "bilious" attacks, asthmatic seizures, palpitation of the heart, shortness of breath, are among the symptoms which may be caused by chronic inflammation of the kidney even before dropsy has become apparent. These it is true, are more frequently misleading in cases of renal cirrhosis, since this latter condition is, as a rule, not accompanied by the œdema which usually attracts the attention early in the course of chronic nephritis. If we would make it a rule to examine the urine at least chemically in every case, if the fact were generally appreciated that such examination is at least as necessary to a knowledge of the patient's condition as the feeling of the pulse, it is probable that chronic nephritis would be oftener detected at an early stage. In every case of obscure difficulty affecting the general nutrition of the patient or any of the internal organs, repeated examinations of the urine, chemical and microscopical, are absolutely essential. At present it happens but too often that no suspicion of renal disease is entertained until the patient is alarmed by the swelling of his feet.

Among the earliest symptoms of chronic nephritis is emaciation; this is usually accompanied by a decided impairment of strength, sometimes amounting to absolute debility. In many instances there occur, even at an early stage, derangements of the alimentary canal; the appetite is impaired, the digestion poor, and the bowels irregular. It sometimes happens that the emaciation and debility are regarded as the result of this digestive disturbance, or conversely, where, as a matter of fact, both are secondary to the more profound disturbance associated with renal inflammation.

Dropsy occurs in almost every case sooner or later. It is often noticed at first in the feet, apparent in the evening and disappearing during the night. In other instances it may be general from the beginning, involving the subcutaneous tissue of the face, trunk, and limbs, and filling the serous sacs even before the skin is greatly swollen. In still other instances the dropsy is confined to one or more localities, the scrotum being often involved. Œdema of the glottis constitutes a dangerous complication, usually occurring in connection with general dropsy, but sometimes (especially in cases of syphilitic origin) appearing suddenly and without extensive œdema.

Acute inflammations of serous membranes frequently occur in the course of the disease and sometimes usher in the attack. Bronchitis and pneumonia, œdema of the bronchi and lungs are also observed, the latter sometimes before the general dropsy is excessive. The appetite is usually impaired; indigestion with or without vomiting, and obstinate diarrhœa

indicate derangement of the alimentary function. Impairment of vision is frequent; it usually occurs gradually, and not suddenly, as in acute nephritis; it is often explained by the appearance of the retina, which indicates localized inflammation. Catarrhal or purulent inflammation of the middle ear is an occasional complication. Pronounced pallor, emaciation, and debility indicate the imperfect state of nutrition which prevails throughout the body. The pulse and temperature may remain normal, though occasional elevations of the body heat are transiently observed and the pulse is at times small and feeble.

Cardiac hypertrophy occurs not only in those cases in which renal cirrhosis is developed, but also where no such change in the kidney is perceptible post-mortem; according to the observations of Ewald and Leyden, it exists in about one-half the cases of large white kidney, though never in the same degree as when associated with renal cirrhosis. Acute dilatation of the heart, usually transient, has been noticed (Heitler) accompanied with dyspnœa and cyanosis.

In a certain percentage of cases hyperæsthesia and paræsthesia in various parts of the body constitute a prominent, sometimes indeed the first symptom. Occasionally the patient complains that joints of fingers and toes seem to be numb and dead; or they may be the seat of intolerable itching.

The urine furnishes most characteristic and important signs in chronic nephritis. The quantity is usually diminished, sometimes even to 300 or 400 c.c. Such oliguria is, however, transient; the quantity varies extremely, and may temporarily exceed that of health. The specific gravity varies inversely as the quantity, sometimes reaching 1.030 or even 1.040 when the oliguria is pronounced, and again sinking to 1.010 or 1.005 when the urinary excretion is more profuse. The urine has usually a dark brown or reddish color and is turbid; the turbidity depends partly upon the anatomical elements of the kidney and urinary channels present, and partly upon the acid urates which are kept suspended in the albuminous fluid. The urine contains albumen, often in large amount, which may reach from two to four per cent. by weight of the fluid; the percentage varies on different days and at different hours of the same day; it occasionally happens that the urine is transiently free from albumen The reaction is commonly acid.

The urinary solids are usually excreted in less than the normal amount, even at an early stage of the disease; this is especially true of urea and of the phosphates. That the activity of the kidney is seriously impaired is shown by the slow excretion of various medicaments, whose presence in the urine can be detected; this tardiness of excretion has been especially demonstrated in the case of the iodide and bromide of potassium. The fact is one of great practical importance; for there may readily occur a gradual accumulation of remedies in the blood of patients suffering from chronic nephritis; the administration of narcotics, for example, in the usual doses and at the ordinary intervals may result in narcotic poisoning in consequence of the diminished excretory activity of the kidney. Jaarsveld and Stokvis have discovered that during chronic nephritis benzoic acid administered by the mouth is not converted into hippuric acid, although healthy kidneys always effect this change.

Although the quantity of urea excreted is usually less than in health, uræmic poisoning is by no means frequent. The explanation lies doubtless in the fact that the quantity of urea produced is much less than in health. The patient consumes less nitrogenous food, and tissue metamor-

phosis is less active than in the normal condition; hence, although the excretion of urea and salts is less than that of a healthy person, it is usually sufficient to prevent the accumulation of these urinary ingredients in the blood. Much urea and urinary salts are also stored away in the œdematous fluid throughout the body—a fact of practical importance; for Bartels has observed violent uræmic convulsions induced by profuse diaphoresis (warm baths); the uræmic intoxication in this case is brought about by the return into the blood of the dropsical fluid containing urea and salts, the absorption of this fluid being promoted by excessive perspiration.

The urine precipitates a thick white sediment; microscopic examination shows an abundance of tube-casts, at first chiefly hyaline but afterward granular, fatty, and epithelial as well. At a more advanced stage, broad, indented casts of glistening appearance are observed, suggesting the amyloid degeneration. Yet this degeneration cannot be assumed upon the presence of occasional casts of this variety alone, since they are found in cases of simple chronic nephritis. On the other hand, the same causes which produce chronic nephritis are also productive of amyloid change, so that the two often occur in the same kidney.

Fig. 11.—Sediment from Chronic Parenchymatous Nephritis, containing hyaline, granular and fatty casts, fatty epithelial cells and granules.

The epithelial cells from the kidney which are found in the sediment of chronic nephritis are not usually recognizable as such, since they are far advanced in fatty degeneration. Distinct epithelial casts are comparatively few, while highly granular casts (derived from the epithelium) are very numerous. Leucocytes are usually found in abundance, and red corpuscles can often be discovered; in exceptional cases the quantity of blood is large.

The abundance of hyaline and granular casts has been already referred to as characteristic of chronic nephritis in distinction from other forms of renal disease. In a few cases this feature is, however, absent; Ackermann observed such an instance, in which, during the last three months of life, tube-casts could rarely be found, although they had been previously abundant; upon section the pelves of the kidneys were found to contain several drachms of yellow slimy liquid, found upon microscopic examination to be filled with tube-casts which had settled in the pelvis and had not escaped with the urine.

Course and Duration.—The disease is frequently fatal within a year, but has been known to last for six and even eight years. It is often complicated by acute exacerbation, or rather by the occurrence of acute nephritis, to which the chronically inflamed kidney appears especially predisposed. Such attacks are accompanied by the appearance of blood in considerable quantity in the urine. On the other hand, remissions often occur; the

excretion becomes more abundant, the dropsy diminishes, the albumen disappears from the urine, and the patient's general condition improves so much as to encourage the hope of recovery. Yet either from some imprudence on the part of the patient or from unknown causes, the symptoms of the disease usually recur with their original force.

The fatal termination may result directly from any one of several complications. Intercurrent inflammations of the serous membranes or of the lungs frequently cut short the life of the patient; erysipelas and gangrene of the skin may follow incisions for the relief of the dropsy, or spontaneous bursting of the skin; indeed, they may occur without any solution of continuity. Thrombosis of veins followed by embolism in the lungs or the brain is sometimes observed; suffocation may result from extensive and sudden effusion of serum into the pulmonary alveoli, the bronchial tubes, or the glottis; obstinate diarrhœa and dysentery may hasten the exhaustion of the patient; and general marasmus usually occurs if the patient escape a fatal result from these complications. In comparatively rare cases death results from cerebral hemorrhage; uræmia is less frequent than in renal cirrhosis.

In other instances the two most prominent symptoms—dropsy and albuminuria—disappear almost entirely; the urine is now excreted in excess and contains only a trace of albumen; the patient's general condition improves. These signs usually indicate, not the subsidence of the renal affection, but its transition to the condition of so-called interstitial inflammation, which may permit the individual to live for several years in comparative comfort, but is sure to terminate fatally. The development of increased arterial tension and of hypertrophy of the heart confirms the belief that such transition is occurring.

Wagner has recently described under the name "chronic hemorrhagic Bright's disease without œdema" a form of renal inflammation characterized by recurring hæmaturia (which may last for several days and be observed at intervals of weeks or months), and by an entire absence of œdema. During these intervals the urine resembles that of renal cirrhosis. The general health is not materially disturbed; the disease may last two or more years. Aufrecht regards this as a chronic interstitial nephritis with periods of hemorrhagic inflammation; this conception meets a serious objection in the fact that cardiac hypertrophy is usually absent.

Bartels describes as "attacks of intercurrent acute nephritis in the course of renal cirrhosis" a condition which Fürbringer's investigations lead him to regard as "acute hemorrhagic Bright's disease during chronic nephritis previously devoid of symptoms." Neither the history nor the examination of the urine reveals a chronic inflammation of the kidney; there may be even no albuminuria; the physician is consulted either because of the hemorrhagic attack or on account of some complicating affection, especially consumption. The acute renal symptoms may subside and the urine become perfectly normal; the diagnosis of chronic nephritis rests, therefore, upon the post-mortem examination. The case commonly results fatally at an early date, though rather from the complicating disease than from the nephritis.

Diagnosis.—The recognition of chronic nephritis is usually easy after the dropsy has become a noticeable symptom. From acute nephritis it is distinguishable by the history alone; also by the absence of blood from the sediment, extensive dropsy, and nature of the casts. It is to be remembered that an acute nephritis may complicate a chronic renal inflam-

mation, in which case the diagnosis rests upon the symptoms and previous history.

From renal cirrhosis chronic nephritis is distinguished by the fact that the former is rarely accompanied by dropsy; in it the excretion of urine is excessive, the albumen slight, and the sediment small; moreover, hypertrophy and dilatation of the heart and an abnormally tense pulse are almost constant symptoms of renal cirrhosis; albuminuric retinitis and uræmic attacks frequently occur. At a later stage, when contraction of the kidney has taken place, the symptoms are practically indistinguishable from those of renal cirrhosis; for the disease is essentially identical in both cases. A previous history of dropsy, pronounced albuminuria, etc., shows that the present affection is a sequel to chronic nephritis rather than a primary lesion.

The distinction of chronic parenchymatous nephritis from simple amyloid degeneration of the kidney is often difficult and even impossible. Etiology, symptoms, and urinary appearances may be identical or at least indistinguishable in the two; moreover both affections are often present in the same case, induced by a common cause. In renal inflammation the casts observed in the urine usually show decided fatty degeneration of the epithelium, which is less pronounced in the amyloid condition; in the latter the excretion of urine is often greater than normal, while in the former it is less. In chronic renal inflammation there is usually an abundant sediment of casts and epithelium, while in the amyloid degeneration there may be no appreciable sediment. Enlargement of the liver and spleen and a persistent diarrhœa are more frequently symptoms of the amyloid change than of chronic nephritis. Yet none of these differences can be relied upon for a positive diagnosis between the two affections; fortunately such differential diagnosis is not absolutely essential in treatment.

Previous to the appearance of dropsy, the recognition of chronic nephritis is difficult and uncertain; in a few cases persistent albuminuria and the presence of granular casts in the sediment reveal the cause of the obscure derangement of nutrition and functions which is usually present; but it must be remembered that even persistent albuminuria of slight degree does not, in the absence of granular casts, necessarily prove the existence of renal inflammation. If there be decided loss of flesh, debility, persistent diarrhœa, irritability of the stomach, or other impairment of function of obscure origin, careful and repeated examination of the urine should be made; a history of previous syphilis, malaria, scarlet fever, or repeated pregnancies constitutes an additional reason for thorough examination of the urine.

Attention has already been directed to the fact that general arterial anæmia, with or without venous congestion, may cause albuminuria and œdema of the feet; this condition is frequent in cases of valvular heart disease, chronic malarial infection, advanced consumption, etc. The absence of pronounced renal disease can be determined in such cases only by a microscopic examination of the sediment, which reveals the absence of epithelial and granular casts.

Prognosis.—This is generally unfavorable; yet instances of recovery from chronic nephritis (or perhaps amyloid degeneration of the kidney, from which the former affection is often indistinguishable intra vitam) are well authenticated. In these cases the renal affection seems to have been induced by syphilitic or malarial affection and to have yielded to specific treatment. In such instances a return of the symptoms is apt to follow,

though these can be again dispelled by similar treatment. It is therefore extremely important to ascertain if possible the presence of such infection as a guide to prognosis as well as to treament; and to remember that a chronic nephritis due to syphilitic infection and yielding to specific treatment, may occur in an individual who has been for years entirely free from other evidences of the specific taint. The renal symptoms may exist without any other manifestation of syphilis, and simply in consequence of exposure to cold or errors in diet. Eichhorst relates the following case: A man acquired syphilis at the age of twenty-five; six months later albuminuria and the signs of chronic parenchymatous nephritis were observed, but disappeared under the use of mercurial inunctions and sulphur baths. Four years later a relapse of the renal affection appeared without perceptible cause and was again cured by antisyphilitic remedies. Fifteen years after acquiring syphilis, and ten years after the last manifestation of the infection, the patient had a third attack of chronic nephritis, promptly cured by the iodide of potassium and iron. In the absence of this or other specific infection, but little hope of recovery can be entertained; a comparatively sudden onset of the disease, the early appearance of dropsy, and pronounced albuminuria offer a better prospect of recovery than the more insidious and chronic attack.

Treatment.—The therapy is determined by the etiology of the disease in those cases in which it can be traced to a definite and specific infection. The existence of a syphilitic or malarial taint, even though it have been long latent, is an indication for the use of remedies especially adapted to the relief of these affections. In some cases the nephritis can be traced with considerable probability to some other morbid condition, the removal of which may perhaps be followed by recovery from the renal complaint; thus it has repeatedly happened that a nephritis developed in the course of chronic suppuration, has subsided upon the cessation of this discharge; and Bardeleben saw a recovery after amputation of a leg which had been the seat of chronic suppuration. It is just possible that the renal complaint in these surgical cases was not inflammation but amyloid degeneration.

If the nephritis cannot be traced to any one of these definite and remediable morbid conditions, there appears to be no way for influencing directly the condition of the kidneys. The indications for treatment are in that case: first, to improve the condition of the blood, by supplying the needed ingredients and by removing the urinary constituents with which the circulating fluid is encumbered; and second, to prevent and relieve, so far as possible, the complications which frequently accompany the complaint.

The first indication, the repair and maintenance of nutrition, must be secured by a proper diet rather than by medicines, though these have an important subordinate position. The regulation of the diet is often a perplexing matter; for the alimentary canal is so irritable that the most nutritious diet provokes gastric uneasiness, vomiting and purging. If the stomach and bowels permit, the patient should partake liberally of fish, eggs, milk, vegetables, fruits, and fat meat, and sparingly of lean meat. If the stomach be too irritable to permit a mixed diet, or if such food seem to aggravate the symptoms, careful experimentation must discover what nutritious articles are best retained and digested. An exclusively milk diet has been much recommended, and has proven extremely beneficial to those patients who can comfortably digest three to four quarts of unskimmed milk daily. The quantity of urine is increased,

the amount of albumen diminished, gastric and intestinal complications are subdued, and the general condition much improved. Unfortunately many patients cannot endure such diet, even with the addition of coffee or cognac, as recommended by Wagner; yet by combining other food with milk at first, the patient's stomach can sometimes be educated to the exclusive milk diet.

Whatever articles of food be selected, care should be takent hat albumen is supplied in abundance; for the patient is suffering a constant drain, amounting perhaps to two, three, or even four drachms of albumen daily. This loss of nutritious material must be supplied, even if the albumen excreted in the urine increases somewhat upon such diet. For so long as the blood receives from the stomach more albumen than is lost through the kidneys, the exact degree of albuminuria is a minor item, since we have no proof that the passage of albumen into the urine aggravates in any way the renal affection.

Another important item is that food should be supplied at short intervals and in comparatively small quantities.

The subjects of chronic nephritis are invariably anæmic and derive much benefit from the continuous administration of iron. The tincture of the chloride combined with sweet spirits of nitre is generally well borne; five to fifteen minims may be administered three times daily. If it cause distress at the stomach, Basham's mixture should be tried; this may be prescribed as follows:

Tinct. ferri chloridi.... ʒ ijss.	Syrupi simplicis,
Acidi acet..... ʒ ij.	Aquæ.....ad. ℥ vi.
Liq. ammon. acetatis.. ℥ iij.	

M. S. Tablespoonful three times a day in half a glassful of water.

The citrate of iron and quinine is also a good form for the administration of this remedy. Advantage may be derived by combining strychnine, quinine, or gentian with the iron; the following prescription is useful in such cases:

Ferri redacti..... gr. xv.	Ext. nucis vomicæ..... gr. iij.
Quiniæ sulphatis..... gr. xx.	

M. Fiat pil. no. xx. S., one before meals.

The drain upon the system, compensated in some degree by food and drugs, can be much diminished by bodily rest. This is a most important item, the value of which is readily seen by comparing the condition of the patient and of the urine during a period of activity with that observed during an interval of rest in bed. Another advantage derived from repose is the avoidance of sudden changes in temperature. It is not intended that the patient should be confined to a close room; air and recreation are essential, but they should be secured with the least possible expenditure of force.

In order to relieve the kidneys of functional activity and to secure the excretion of the urinary ingredients, the skin and the bowels should be kept active. Except in the later stages of the disease, a sufficient degree of cutaneous activity can be secured by warm clothing and frequent warm bathing. The patient should wear flannel next the skin in all seasons, and should most carefully avoid exposure to cold and draughts; indeed, if circumstances permit, he should reside in a dry, warm climate which does not

exhibit sudden changes of temperature. It may become necessary to secure additional excretion by the skin; in this case pilocarpine may be administered. Frequent warm baths and an occasional wet-pack will do much toward promoting cutaneous activity without the depressing and injurious effects of more vigorous measures. (See Treatment of Acute Nephritis, p. 194.)

Laxatives should not be employed until it becomes evident that the skin alone is incapable of supplementing completely the renal function; for the intestinal tract is usually in a state of irritation, diarrhœa being a frequent feature. When the dropsy has become excessive, however, it is necessary to produce purgation; this should also be induced at the first intimation of uræmic poisoning. Elaterium—one-eighth to one-fourth of a grain—or a drop of croton-oil may be occasionally employed; for more habitual use, the compound jalap powder or Hunyadi water is less objectionable. Free purgation rapidly affects the patient's strength as well as the dropsy, and should be discontinued so soon as the imperative indication for its employment has passed.

As to the kidneys themselves, but little can bed one. By regulating the diet and by prohibiting active exercise, the amount of urea produced can be kept at a minimum and the demand for secretory activity in the renal cells correspondingly reduced. By the ingestion of an abundance of pure water, the urine is diluted and the products of inflammation removed from the capsules and tubules; the patient should drink habitually a mild alkaline water containing but little if any of the potassium salts. The importance of this measure is scarcely appreciated among us; our mineral waters are but too often prescribed promiscuously and empirically, without an intelligent appreciation of the objects to be attained or the means for attaining them. The sufferer from chronic nephritis is benefited by the free use of an alkaline water which does not contain an excess of mineral ingredients. Under its use disorders of the stomach and intestine are much improved, the albumen excreted is diminished, the dropsy decreases, and the excretion of solids is often increased. Without ignoring the other factors which exert a beneficial effect at the different springs, it is certain that the free use of the waters alone is a most valuable feature in treatment. This has been often demonstrated of the Vichy, Carlsbad, and Marienbad waters; they can be taken in quantities sufficient to produce a marked effect upon the urine and upon the general health, without irritating the intestines. The waters more heavily laden with laxative salts—such as Hunyadi Janos—should be avoided. The effects of the various mineral waters of the United States have not been so carefully studied as to permit a positive statement as to their individual applications; those of the Arcadian Spring, Waukesha, Wis., and the Buffalo Lithia, Va., are among the best.

If the patient can be persuaded to drink an abundance of such mild alkaline water—the quantity being regulated by the effects in each individual case—no diuretics are required; otherwise the excretion of urine should be furthered by using the citrate or acetate of potassium, which may be combined with the infusion of digitalis if the heart's action be feeble. Malt liquors are allowed in moderate quantity, but wines and whiskey should be employed as stimulants only, if at all. In administering medicines as well as food extreme care should be taken to avoid irritation of the stomach.

Various remedies have been at different times asserted to possess the power of diminishing the excretion of albumen in chronic nephritis; tannic

and gallic acids, eucalyptus, ergot, nitric acid, and more recently fuchsin and nitro-glycerine, have been employed for this purpose with, at best, doubtful success. Possibly each of the remedies has conferred benefit in particular cases ; but their promiscuous employment has certainly failed to substantiate the claims made for them.

Excessive dropsy requires mechanical relief ; the fluid in the serous cavities can be removed by the aspirator, and in the subcutaneous tissue by Southey's tubes or nickel-plated hypodermic needles. Incisions into the skin should be avoided, since they promote sloughing and erysipelas. Excoriations, which frequently occur on the scrotum and thighs, can be often healed by dusting with the oleate of zinc.

The patient should be impressed with the necessity for a careful observance of the hygienic and dietetic requirements of his unfortunate situation ; for in this way he will secure the greatest probability for avoiding the complications which so frequently terminate the case.

Disorders of the stomach and bowels often complicate the case and render treatment more difficult. These disorders are often due to œdema of the intestinal and gastric mucous membrane ; their successful management requires the use of measures which diminish the general dropsy.

Cirrhosis of the Kidney.

Renal cirrhosis, or chronic interstitial nephritis, occurs either as the sequel of chronic parenchymatous nephritis or as a primary affection. It is practically impossible to determine, except by a history of previous œdema, whether or not renal cirrhosis in a given case is primary or secondary.

Etiology.—The disease is observed almost exclusively in middle or advanced life, though it is occasionally found in young persons, in children, and even in infants ; Buhl records a case in a child eighteen months old.

The causes of the affection are chiefly certain influences peculiar to adult life ; several of these are well ascertained. Gout is a frequent precursor of renal cirrhosis, which is undoubtedly caused by the same factors that induce the gouty condition ; possibly the retention of uric acid in the blood, demonstrated in cases of gout, may be the exciting cause.

High living, with or without the development of gout, is certainly a sufficient cause, presumably through the overstimulation of the kidneys in the effort to remove the excessive nitrogenous waste material derived from the food. The abuse of alcoholic liquors is frequently followed by renal cirrhosis, which, with cirrhosis of the liver, is often seen in the habitual drinker ; the Germans are inclined to doubt the frequency of this affection as a result of alcholic excess. Lead poisoning is a frequent cause ; it is possible that chronic poisoning with other metals may also produce it.

Chronic inflammation of the urinary passages, pyelitis, cystitis, and stricture are sometimes followed by renal cirrhosis ; the connection between the two is not clear ; possibly there occurs an extension of the inflammatory process, though the autopsy does not as a rule support this view. Some authors are inclined to ascribe the renal affection to the injurious influence on the kidneys of the various balsams and oils which are so commonly used in the treatment of inflammations of the bladder and urethra.

Various constitutional conditions also predispose to it ; syphilis, ma-

larial fevers, chronic disease of bone, while more frequently producing amyloid change or chronic parenchymatous nephritis, are also held responsible for renal cirrhosis. From the frequency of this affection in men of the upper classes, it has been assumed that prolonged mental anxiety is sufficient to induce the disease; yet it is especially difficult to eliminate the other possible influences to which such individuals, frequently given to excesses of various kinds, are exposed.

Hereditary influence is by most writers considered an important etiological factor. It is certain that various members of the same family are frequently the subjects of the affection; thus Eichhorst mentions a family, several members of which have come under his own observation: the grandmother died of renal disease with uræmia, the mother has had for fifteen years the symptoms of renal cirrhosis, two sons died of uræmia, and a daughter twenty-two years old has the signs of cirrhosis of the kidney. While the facts are undoubted, it may be a question whether the predisposing influence in the different members of the same family is hereditary or consists in the common exposure to other causes resulting from a common mode of life.

In a considerable number of cases no antecedent cause or predisposing influence can be discovered. The renal affection appears to be merely one manifestation of a general disease of the arteries throughout the body. Since these cases are especially frequent in advanced life, it has become the custom to regard senility itself as a predisposing influence or even a cause.

Morbid Anatomy.—The anatomical appearances vary extremely according to the stage of the disease as well as with the etiological influences. While chronic interstitial nephritis is clinically a unit regardless of the etiology, several distinct types of morbid kidneys are recognized anatomically, dependent largely upon the cause of the affection.

The two most prominent types are those designated by English authors as "the red contracted kidney" and the "granular kidney." The former of these presents the appearances observed in cases of primary renal cirrhosis, while the latter is usually found as the contracting stage of the large white kidney. Numerous transitional forms are found.

The red contracted kidney is much reduced in size and weight, measuring often only one-half of the normal. The surface is reddish brown, uneven, and granular; the prominences of this surface may be of uniform size and generally diffused, or of varying dimensions and limited to certain localities. The protuberances exhibit the reddish-brown color characteristic of the organ, while the fissures between them are of a grayish or white tint. This difference in color corresponds to the difference in structure, the prominences being composed of renal tissue, the fissures of connective tissue.

The capsule is thickened, opaque, and adherent to the parenchyma, especially over the cicatricial depressions; the blood-vessels of the capsule are frequently enlarged and communicate freely with the vessels of the fat mass surrounding the organ. The renal vessels at the hilus often exhibit anatomical changes; the renal artery especially is apt to be thickened and hard; occasionally thrombosis of the renal vein is observed.

The cortical substance is remarkably narrow and at points almost obliterated. Both this and the medullary part exhibit numerous cysts, rarely exceeding the size of a pea, and filled with a gelatinous or semi-purulent mass. These may be located also upon the surface of the kidney projecting above the general level. The pelvis of the kidney is usually large and often exhibits catarrhal or even purulent inflammation.

The gouty kidney, as well as that which follows chronic poisoning with lead or alcohol, presents essentially the same features. In cases of gout there are often found infarcts of uric acid and urates, which appear as grayish stripes in the medullary portion and whitish points in the cortex. These infarcts are located chiefly in the lumen of the urinary tubules, but also in the interstitial connective tissue.

These changes are observed in both kidneys as a rule, though frequently more advanced in one than in the other; indeed, different portions of the same kidney may exhibit great differences in the stage of the affection, some parts even of small kidneys retaining an approximately normal appearance.

Upon microscopic examination of the kidney, the most prominent abnormal feature is the excess of interstitial connective tissue. This is evident not simply by the increase of the intertubular spaces, but also by the disappearance of the proper kidney structure in certain portions of the organ, where it is replaced by broad bands of connective tissue. In other portions there are found masses of brown cells indicating the continuation of the connective tissue formation. Many of the glomeruli are shrunken and surrounded by a stratified capsule many times the normal thickness; other tufts are completely obliterated, the space being occupied either by a mass of connective tissue or by a homogeneous, hyaline structure. The cells of the tubules are granular, and in many parts absent altogether, the tubules being collapsed and obliterated. The cysts so often found in cirrhotic kidneys arise partly from the tubules and partly from the glomeruli. In the former case the lumen of the tubule is at some portion compressed by connective tissue, after which the cavity above this point becomes dilated and filled with a colloid, gelatinous material which appears to result largely from metamorphosis of epithelial cells, and in which leucin and tyrosin are frequently found.

In this form of renal disease the blood-vessels are always thickened, chiefly by a new formation of connective tissue just under the internal coat of the small arteries—"endarteriitis obliterans;" this thickening may become so great as to occlude the lumen of the vessel entirely. The vascular wall presents in many cases a hyaline appearance resembling the amyloid degeneration, but not responding to the reaction with iodine. This form of thickening affects especially the middle and outer coat of the arteries; it has been described by Gull and Sutton as "arterio-capillary fibrosis."

In the renal sclerosis which is secondary to chronic parenchymatous nephritis, the kidney presents a somewhat different appearance. The surface is more uneven, the granulations larger, the color yellow (from fatty degeneration of the epithelium), and the cysts less numerous. Microscopically less connective tissue is observed. The granulations present do not necessarily depend upon diffuse interstitial thickening, since they are often found in cases where but little increase of connective tissue is observed. Conversely, the absence of granulations does not prove the absence of interstitial hypertrophy, since, as Leyden has shown, the large white kidney, presenting a smooth surface, often shows extensive increase of the connective tissue and the symptoms of chronic interstitial nephritis.

Renal cirrhosis is accompanied with abnormal conditions of other organs. Foremost among these are the changes observed in the circulatory apparatus: the heart is found in a state of dilatation and hypertrophy, usually of the left ventricle only, though sometimes of both sides; fatty degeneration is often present in circumscribed areas. Inflammation of the heart-muscle in the areas of obliterated blood-vessels is also noticed.

Endocardium and pericardium are often the seat of inflammation, recent as well as old; thickening and calcification of the valves, fatty degenerations of the endocardium and aortic wall are not infrequent; transudation, exudation, and adhesions are found in the pericardium. The larger vessels, especially those at the base of the brain, are thickened, their calibre diminished, and the lumen sometimes obliterated (endarteriitis obliterans).

The other serous membranes, particularly the pleura and peritoneum, are occasionally found in a state of inflammation, old or recent. The lungs exhibit catarrhal inflammation with or without œdema. The mucous membranes, especially the bronchial and intestinal, are in a state of catarrh, often showing blood extravasations and (intestinal) ulceration.

The liver frequently exhibits evidence of cirrhosis. Thickening of the arachnoid and dura, sometimes inflammation of the same, is observed; œdema of the brain is an occasional appearance. Extravasations within the cranium and in the retina may usually be discovered. Bartels asserts the frequent occurrence of thickening of the cranium bones. Amyloid degeneration of the kidney as well as of the spleen and liver are occasional accompaniments of renal cirrhosis.

Symptoms.—The development of interstitial nephritis as a continuation of the chronic parenchymatous inflammation, is revealed by the gradual disappearance of the dropsy, the diminution in the percentage of albumen, the increased excretion of urine, and the appearance of decided cardiac hypertrophy.

The more frequent chronic interstitial nephritis which begins, not as a sequel to an earlier stage of renal inflammation, but as a primary affection, is extremely insidious in its approach. At an advanced stage renal cirrhosis is marked by evident and unmistakable symptoms; but during the earlier part of its course it is often unrecognized and even unsuspected. For the symptoms caused by early cirrhosis do not attract attention to the kidney; in fact, the disease may appear primarily as an affection of the arterial system, so that the symptoms caused by it may be exhibited by arterial derangements in other organs. Thus a patient may die suddenly from cerebral hemorrhage, and the post-mortem reveals cirrhotic kidneys, though no suspicion of renal or perhaps of other disease had been entertained. Another suffers from indigestion, and has frequent headaches, perhaps accompanied by epistaxis; the latter symptoms are referred to the gastric disturbance, until albumen is discovered in the urine. In fact, the greatest diversity of symptoms may be manifested in various organs as a result of that condition.

Derangements of the circulatory organs may be long exhibited without symptoms which call attention to the kidneys. The patient complains for months of nothing else than a constant and annoying palpitation of the heart, especially frequent after physical exertion or mental excitement, but often occurring without appreciable cause. Shortness of breath without discoverable lesion of the thoracic organs is also an early symptom. Persistent headache, especially hemicrania, or neuralgia may call for treatment; these are often accompanied by vomiting, which occurs particularly in the morning—a combination of symptoms that may, under certain circumstances, lead to a presumption of pregnancy.

Chronic rheumatism affecting the joints as well as the muscles, and often accompanied by paroxysms of sharp pain; profuse and persistent bleeding at the nose, hemorrhage from the stomach or bowels; dyspepsia, chronic diarrhœa, and frequent vomiting—any of these may be regarded as

primary affections until the subsequent history of the case or a closer examination reveals a lesion of the kidneys.

In other instances the first symptoms may be failure of the sight, amounting perhaps to complete blindness in one or both eyes; this loss of vision may be sudden, but is more frequently a gradual impairment, the true nature of which is recognized by examination with the ophthalmoscope. It occurs in about one-fourth of the cases of renal cirrhosis, far more frequently, therefore, than in other forms of renal disease. Roaring in the ears accompanied by a feeling of faintness, and deafness, produced by many different causes, are in some instances attributable to the disease in question.

Persistent and recurring hoarseness (from chronic œdema of the laryngeal mucous membrane) has been noted by Waldenburg as a precursor of the more pronounced symptoms of interstitial nephritis.

Affections of the nervous system of the most diverse nature originate in this same condition; headache, hemicrania, have been already mentioned; a prominent symptom may be insomnia, often so pronounced as to require the use of anodynes. Neuralgias of various portions of the body, often in the shape of obstinate sciatica, may long be the only manifestation of the latent disease. Epileptiform convulsions, produced by chronic uræmic poisoning or by genuine meningitis, are sometimes noticed.

Cases are recorded in which the individual was treated for weeks for supposed malarial poisoning; the frequent chills and fever manifested were ultimately discovered to originate in chronic uræmia from renal cirrhosis. Asthmatic attacks are recognized as one of the early symptoms of this disorder; shortness of breath is often seen before and after the stage of compensatory cardiac hypertrophy, and may occur suddenly during the existence of such hypertrophy from acute dilatation of the heart. In a certain number of cases there occurs general emaciation and debility without apparent cause; there may be no symptom pointing to a lesion of the kidney or of other organs until an examination of the urine is made.

Inflammations of internal organs are frequent and often overlooked because they are accompanied with less fever and constitutional disturbance than is usually the case. This is especially true of lobar pneumonia, pericarditis, and pleurisy; any one of these may exist in the subject of renal cirrhosis without occasioning such pain or rise of temperature as would direct attention to the part in question. In one personal case a man of sixty-three, long the subject of renal cirrhosis, but enjoying very fair health, complained of nausea, loss of appetite and general malaise; the temperature was only 99.5°, there was no complaint of pain, nor did the urine exhibit any decided change from its usual condition. The feebleness of the pulse, contrasting strongly with its previous tension, led to an examination of the heart; an extensive exudation in the pericardium was detected. At the autopsy, two days later, the diagnosis of pericarditis was confirmed.

Uræmia may manifest itself in most diverse ways: sometimes it is as dyspepsia and chronic diarrhœa, with or without vomiting; sometimes it appears as asthma or obstinate bronchitis; again it may be manifested by convulsions, which are indeed occasionally the first symptoms leading to a thorough investigation of the case. Any of these conditions in an individual more than thirty years of age, should be a signal for repeated examinations of the urine; on the other hand, every patient known to suffer from renal cirrhosis should be submitted to a thorough examination of in-

ternal organs—the heart and lungs especially—when a temporary failure of the health is observed.

Since none of these symptoms point directly to the kidney as the source of the difficulty, or as the organ in which the general morbid condition can be detected, the examination of the urine is but too often overlooked; or if made, it consists merely in testing a single specimen for albumen. Such examination often furnishes negative results, which may be regarded by the physician as conclusive proof that the kidneys at least are not at fault; his attention is therefore directed to other organs, and the real difficulty remains for a long time undiscovered. There are various objective symptoms which may lead the physician, or even the patient himself, to suspect renal disease and thus cause an early examination of the urine; among these are frequency of urination, especially at night; slight swelling of the feet; firmness of the pulse, pulsation of the temporal arteries, pallor and dryness of the skin. Thirst and increased excretion of urine may lead the patient to fear that he is the subject of diabetes. In comparatively few cases the one symptom known to the laity as an indication of renal disease —dropsy—is present; this occurs but rarely in primary renal cirrhosis. A slight swelling of the feet and ankles, causing an unusual tightness of the boot, may escape detection; more pronounced dropsy is seen only when, from some failure of the circulation, often temporary, the urinary secretion does not attain its usual amount; such causes are fatty degeneration of the heart, pericarditis, endocarditis, exposure to cold and moisture. Even in these cases the œdema and slight albuminuria, if detected, may be mistaken for consequences of the cardiac condition.

The earliest, most pronounced, and constant symptoms of renal cirrhosis are observed in the circulatory system; indeed, the heart and arteries furnish information quite as significant and essential as the urine. The condition of the pulse, which is hard, full, and quick, is often of itself sufficient to direct attention to the urine. Actual measurements of the pulse show that the tension is really increased in this disease as much as fifty per cent. above the normal; sphygmographic tracings also show the unnatural tension of the artery by the secondary waves. This condition of the pulse is associated with hypertrophy of the left ventricle or of the entire heart. Such hypertrophy is in itself, in the absence of valvular disease, sufficient to arouse a suspicion of renal cirrhosis. It is important to remember that in certain cases the heart may exhibit no hypertrophy, even when other characteristic symptoms are present, and when the autopsy reveals contracted kidneys. Cohnheim has emphasized the fact that this absence of cardiac hypertrophy is the rule in those cases in which amyloid degeneration complicates the renal cirrhosis; it is therefore to be expected in the subjects of prolonged suppuration, syphilis, tuberculosis, etc. The result of this hypertrophy of the heart and disease of the arteries is a series of symptoms quite characteristic of the affection—palpitation of the heart, "rush of blood" to the head, congestion of the face, dizziness, epistaxis, and often hemorrhage within the cranium. The so-called gallop rhythm of the heart—a doubling of the second sound—asserted by Potain to be characteristic of renal cirrhosis, has been recently shown by Frantzel to occur in other affections also.

The relation between renal cirrhosis and the coincident cardiac hypertrophy has been the subject of much dispute and investigation for many years past. By some it has been assumed that the cirrhosis was the primary affection, and that in consequence of the occlusion of numerous blood-vessels in the kidneys, the blood-pressure was increased and the hy-

pertrophy of the heart induced. Others have maintained that the general disease of the arteries, in other organs as well as the kidneys, was the primary difficulty and cause of cardiac enlargement. It would exceed our limits to recapitulate the observations, clinical and experimental, which have been adduced to support each of these hypotheses. Notwithstanding the reported demonstration that, by transient ligature of the renal arteries in dogs and rabbits, chronic interstitial nephritis and secondary cardiac hypertrophy have been induced (Grawitz, Israel, Lewinski, denied by Zander), the weight of evidence indicates that the original affection is a disease of arteries throughout the body, as a consequence of which blood-pressure is increased and cardiac hypertrophy induced. Whether or not this general disease of the arteries is a result of the accumulation in the blood of materials which should be eliminated by the kidney, is undetermined.

The diagnosis of the renal participation in the general disease is made by the characteristic appearances of the urine. The quantity excreted is increased sometimes enormously (Bartels records a daily excretion of 12,000 c.c.); from 2,000 to 4,000 c.c. is a frequent daily amount. In many cases the quantity excreted during the night is greater than that passed by day, and the patient's rest is disturbed by frequent calls to urinate. The urine is in consequence of its dilution of unusually light color, often with a greenish tinge; it is of acid reaction, unless rendered otherwise by medication. The specific gravity is less than normal, usually about 1.010, varying with the amount excreted; it is higher by day than at night, corresponding to the lessened excretion during the day. It is remarkable that during intercurrent febrile attacks, the specific gravity remains, contrary to the usual rule, below normal; an observation of this sort should direct attention to the possibility of renal cirrhosis.

The diminution in specific gravity seems to be dependent simply upon the polyuria and not upon a decrease in the amount of solids excreted; for, until the latter period of the disease, the amount of urea and salts remains at or near the normal figure. The phosphates are, however, retained to a considerable extent, and Fleischer observed that phosphoric acid administered to a subject of renal cirrhosis is not excreted as completely as by healthy kidneys. At a later period of the disease there is a retention of all the solid constituents, including urea; indeed, a somewhat diminished excretion of urea is often observed during the earlier course of the disease. Fleischer found that a patient suffering from this affection excreted less urea than a healthy person, when both were kept upon the same diet.

The urine usually contains albumen, though this may be absent for days or weeks at a time—an absence which sometimes misleads the physician who is accustomed to regard non-albuminous urine as proof of the integrity of the kidney. The proportion of albumen is always small, usually not more than 0.1 or 0.2 per cent.; yet such a percentage in so large a quantity amounts to several (three to six) grammes per day. It is noticeable that the urine excreted during the night is more frequently free from albumen than that evacuated during the day, a fact to be borne in mind in determining the nature of the complaint; if the morning urine only be examined, it may be found non-albuminous, yet later in the day it contains albumen. Physical exertion or mental excitement usually causes an increased excretion of albumen; and uræmic attacks or outbreaks of gout are preceded and followed for some time by increased albuminuria.

The existence of renal cirrhosis is not excluded by the absence of albumen even upon repeated examinations, since a few cases are on record in which no albumen was at any time found in the urine, although the section re-

vealed unmistakable cirrhosis and the symptoms other than albuminuria were characteristic. Indeed, Schuchardt records a carefully observed case in which the urine was always normal in every respect until just before death ; the autopsy revealed pronounced atrophy and inflammation of the kidney.

But little or no sediment is macroscopically visible. Upon microscopical examination, however, there are found tube-casts, chiefly hyaline, but occasionally granular (Fig. 12). Now and then a cast studded with cells from the urinary tubules, or with uric acid, urates and oxalate of calcium, is observed. During transient exacerbations of the renal affection, and after uræmic or gouty attacks, a considerable number of epithelial casts and renal epithelial cells may be found in the urine. Leucocytes, and sometimes red corpuscles, are present in small number.

Fig. 12.—Sediment from Renal Cirrhosis.

Course and Duration.—The general appearance of the patient often betrays no especial abnormality, while at other times the skin is unusually pale, dry, and harsh. A frequent symptom is persistent and annoying itching, which is present day and night, and drives the patient to desperation. In other cases obstinate eczema is developed, which yields but slowly to treatment and breaks out afresh without provocation. The general nutrition usually remains unimpaired, though emaciation is sometimes observed, and the individual may complain of corresponding loss of strength. All these symptoms occur, however, less frequently and with less prominence than during the course of chronic parenchymatous nephritis.

The disease may last for many years even after its discovery, and has usually existed for a considerable time before the diagnosis is made or its nature even suspected. On the other hand the life of the patient may be cut short by any one of the numerous complications so often observed, among them uræmia, cerebral hemorrhage, inflammation of the lungs or serous membranes, catarrh of the intestinal tract, or œdema of the lungs or glottis. Recovery from pronounced and undoubted cirrhosis of the kidney has never as yet been reported.

Among the most characteristic, though by no means most constant, symptoms observed are the changes which occur in the retina. These may be suspected from the impairment of vision of which the patient complains ; amblyopia, dimness of vision, muscæ volitantes, and other distortions of the sight occur. An occasional incident is sudden and complete blindness affecting one eye and disappearing in the course of a few days ; in other instances both eyes are simultaneously affected, apparently from no anatomical change, but from incipient uræmia.

In the retina there are observed yellow spots, which often surround the

optic papilla, but more frequently are located in and around the yellow spot, where they are arranged as rays radiating from this point. In other cases the spots have no definite topographical relations either to the papilla or to the macula lutea. These spots are occasioned partly by fatty degeneration in the granular layers of the retina, partly by hypertrophy of the nerve-fibres, both changes apparently resulting from pathological changes of the retinal vessels. Aside from this so-called "retinitis albuminurica" there is observed, in cases of renal cirrhosis, the appearance known as "choked disk," the result of venous congestion. All of these abnormalities of the retina may subside when due to renal cirrhosis; the last named, however, occasionally results in atrophy of the disk. Apoplexy of the retina, as well as of the brain, is often found in these cases of renal disease.

Failure of the hypertrophied heart from fatty degeneration, or acute intercurrent disease, causes a change in the clinical picture: the urine becomes less profuse, the specific gravity somewhat higher, the percentage of albumen is increased, digestive disturbances are aggravated, perhaps slight dropsy becomes apparent, and uræmic symptoms threaten. Secondary dilatation of the heart, causing dyspnœa, asthma, palpitation, etc., may follow.

Diagnosis.—The difficulties of diagnosis arise not from the resemblance of the symptoms to those produced by other affections of the kidney, but from the fact that these symptoms may be exhibited during a long period chiefly or entirely by other organs. After the polyuria, albuminuria, and tension of the pulse are recognized, the diagnosis is easy. A systematic examination of the urine in every case of disease would often reveal an unsuspected renal cirrhosis. It is readily distinguished from acute and chronic parenchymatous nephritis by the profuse excretion of urine, its clear color, low specific gravity, slight sediment, and small percentage of albumen; the absence of dropsy, the presence of lesions in the heart, arteries, nervous system, and eye are additional factors in making up a diagnosis. During acute exacerbation the urine may present the changes characteristic of acute inflammatory process and dropsy may be present; indeed, there may be an acute nephritis engrafted upon an undiscovered renal cirrhosis. After the subsidence of this, however, the features of the latter affection persist. In the absence of cardiac hypertrophy—either from temporary cause or from a complication with amyloid degeneration—the urine may be diminished and the percentage of albumen increased; indeed, dropsy may exist in slight degree.

The distinction from simple amyloid degeneration of the kidney is rarely difficult; for in the latter condition the urine is less abundant and contains a greater percentage of albumen; there is no evidence of cardiac hypertrophy or changes in the retina, while there is usually enlargement of the spleen and liver; the history, too, indicates the origin and nature of the affection. The complication of renal cirrhosis with amyloid degeneration produces a puzzling condition which cannot always be recognized; for there may be no changes in the heart or arteries, while the other symptoms indicate interstitial nephritis. The polyuria may lead to a diagnosis of diabetes insipidus; indeed, it is probable that this mistake is not rare. Careful consideration of the other features in the case will easily lead to a correct distinction between the two.

Senile atrophy of the kidney, though perhaps indistinguishable from renal cirrhosis by post-mortem inspection of the organ, is easily distinguished clinically; for this purely senile atrophy is accompanied with a diminished rather than an increased excretion of urine; there is no cardiac

hypertrophy nor increased arterial tension; albuminuria is rare and uræmia absent.

In his ardent search after latent renal cirrhosis, the physician must guard against the temptation to make this diagnosis in cases of intermittent or persistent albuminuria when the other symptoms are absent; for such albuminuria may exist without any form of renal disease, and its occurrence is usually preceded by symptoms in the circulatory and digestive organs at least which explain the significance of the albumen. The coincidence of increased arterial tension, persistent headache, dyspepsia or diarrhœa with albuminuria, should be regarded as strongly suggestive of renal cirrhosis and as ground for maintaining a constant supervision of the patient. Yet it must be admitted that, even with the most careful attention to all diagnostic points, cases occur in which the presence or absence of renal cirrhosis can be determined only after considerable time has elapsed. It is certain that intermittent or constant albuminuria, even associated with a decided increase of vascular tension, may last for some months and then disappear permanently. Possibly such cases are really instances of incipient or localized renal cirrhosis, or the albuminuria may originate in conditions independent of the kidney. Such cases must be distinguished from those of genuine and undoubted renal cirrhosis in which remissions lasting, perhaps, weeks or months occur, during which periods no albumen is found in the urine.

Prognosis.—No instance of recovery from pronounced and undoubted renal cirrhosis is yet recorded; yet the affection is not incompatible with many years of comparatively good health. Instances are known in which patients have survived fifteen and even twenty years after the detection of the renal affection, and the physical and mental powers are frequently retained without serious impairment for six or eight years. Yet the condition is liable to so many complications, often fatal, that no security to life is afforded. Cerebral hemorrhage, uræmia, œdema of the lungs and glottis, may occur suddenly in the midst of apparent health.

Treatment.—The object of treatment is in the majority of cases merely the protection of the patient from the consequences of the disease; for the nature of the primary affection is often undiscoverable. The attempt to arrest the increase of connective tissue in the kidney by remedies addressed to that organ must be, and as a matter of fact is, futile, since this cirrhosis is merely one result of a constitutional condition. In those cases in which a definite cause can be assumed, such as syphilis or lead poisoning, the administration of remedies known to counteract these specific influences is occasionally followed by success. The iodide of potassium with or without the bichloride of mercury has been known to arrest the morbid changes in the kidneys and arteries, and thus to restore the individual to comparative health. Since, moreover, a syphilitic taint may lurk unsuspected and undiscovered, the iodides may be in almost every case administered with propriety.

In most instances, even in some of undoubted syphilitic history, these remedies produce no appreciable effect in arresting or even retarding the morbid process. Certain other drugs have seemed at times beneficial; thus Bartholow recommends the chloride of gold, and says, "Better results even" (than the iodides), "the author believes, are procured from the careful and persistent administration of the chloride of gold or of gold and sodium." "These remedies, intended to arrest the hyperplasia of the connective tissue, should be prescribed with a definite relation to the presumed cause—iodide of potassium and bichloride of mercury, in those with a

syphilitic history; iodide of potassium in those poisoned by lead; and chloride of gold and arsenic in those cases of unknown origin."

Aside from such measures of doubtful utility, nothing can be done by drugs to check the increase of connective tissue in the kidney or the degeneration and thickening of the arteries. The treatment consists simply in efforts to maintain the nutrition of the patient, and to avoid the numerous complications which beset him in the course of the disease.

A judicious diet constitutes a most important feature of the treatment. The food should be nutritious and plentiful, but contain no more nitrogenous matter than is necessary for health. The diet may consist largely of milk, eggs, and vegetables; fat meat is permissible, but lean meat should be taken sparingly. Wines and liquors of all kinds should be avoided unless required for purposes of stimulation. These dietetic principles, though generally applicable, must not be regarded as inflexible rules; individual wants and peculiarities often require the use of beer or light wines; the obstinate dyspepsia which so annoys and debilitates the person, may be relieved by these when other measures fail. Careful observation of the effects upon the general condition and the state of the urine must constitute a considerable factor in prescribing the diet.

The body should be warmly clothed, the skin being protected by wool in all seasons; the greatest care should be taken to avoid exposure to cold and moisture, since simple wetting of the feet may precipitate a uræmic attack. Residence in a warm, dry, and uniform climate has sometimes seemed to retard or even to arrest the disease.

Rest of body and mind is conducive to the welfare of the patient and the avoidance of complications. Prolonged mental exertion and intense excitement may, like excessive bodily exercise, provoke rapid progress of the disease or the outbreak of complications. It is not desirable to confine the patient to bed or to forbid ample exercise, except during those periods when the heart is especially feeble. It is only necessary to avoid excess of bodily and mental activity which a healthy man may undertake with impunity; for the subject of renal cirrhosis is an invalid, however objectionable and unfounded this idea may seem to him.

The loss of albumen can be readily compensated through the food, and does not constitute an important factor of the complaint.

Among drugs, iron, quinine, and mineral acids may be administered almost continually. After a long course of iron, headache and gastric disturbance are indications for its discontinuance; it should be renewed after an interval of rest. Some experimentation may be necessary to discover the most suitable form for the administration of iron; the most generally useful is Basham's mixture, though the citrate of iron and quinine may be substituted for a time with advantage.

Some of the complications which render this disease so dangerous arise from hypertrophy of the heart and degeneration of the vascular walls. We are acquainted with no means for arresting either of these processes; in fact, an attempt to prevent the cardiac hypertrophy would be unjustifiable and, if successful, disastrous, since the continued activity of the kidney can be maintained only by increased effort on the part of the heart. The only safety against complications on the part of the circulatory organs lies in the avoidance of physical and mental exertion and excitement. At a later period it may become necessary to stimulate rather than quiet the heart; for after a time the compensatory hypertrophy, which at first enables the kidneys to excrete the usual amount of solids, fails to keep pace with the increasing degeneration of these organs, or gives place to

ternal organs—the heart and lungs especially—when a temporary failure of the health is observed.

Since none of these symptoms point directly to the kidney as the source of the difficulty, or as the organ in which the general morbid condition can be detected, the examination of the urine is but too often overlooked; or if made, it consists merely in testing a single specimen for albumen. Such examination often furnishes negative results, which may be regarded by the physician as conclusive proof that the kidneys at least are not at fault; his attention is therefore directed to other organs, and the real difficulty remains for a long time undiscovered. There are various objective symptoms which may lead the physician, or even the patient himself, to suspect renal disease and thus cause an early examination of the urine; among these are frequency of urination, especially at night; slight swelling of the feet; firmness of the pulse, pulsation of the temporal arteries, pallor and dryness of the skin. Thirst and increased excretion of urine may lead the patient to fear that he is the subject of diabetes. In comparatively few cases the one symptom known to the laity as an indication of renal disease —dropsy—is present; this occurs but rarely in primary renal cirrhosis. A slight swelling of the feet and ankles, causing an unusual tightness of the boot, may escape detection; more pronounced dropsy is seen only when, from some failure of the circulation, often temporary, the urinary secretion does not attain its usual amount; such causes are fatty degeneration of the heart, pericarditis, endocarditis, exposure to cold and moisture. Even in these cases the œdema and slight albuminuria, if detected, may be mistaken for consequences of the cardiac condition.

The earliest, most pronounced, and constant symptoms of renal cirrhosis are observed in the circulatory system; indeed, the heart and arteries furnish information quite as significant and essential as the urine. The condition of the pulse, which is hard, full, and quick, is often of itself sufficient to direct attention to the urine. Actual measurements of the pulse show that the tension is really increased in this disease as much as fifty per cent. above the normal; sphygmographic tracings also show the unnatural tension of the artery by the secondary waves. This condition of the pulse is associated with hypertrophy of the left ventricle or of the entire heart. Such hypertrophy is in itself, in the absence of valvular disease, sufficient to arouse a suspicion of renal cirrhosis. It is important to remember that in certain cases the heart may exhibit no hypertrophy, even when other characteristic symptoms are present, and when the autopsy reveals contracted kidneys. Cohnheim has emphasized the fact that this absence of cardiac hypertrophy is the rule in those cases in which amyloid degeneration complicates the renal cirrhosis; it is therefore to be expected in the subjects of prolonged suppuration, syphilis, tuberculosis, etc. The result of this hypertrophy of the heart and disease of the arteries is a series of symptoms quite characteristic of the affection—palpitation of the heart, "rush of blood" to the head, congestion of the face, dizziness, epistaxis, and often hemorrhage within the cranium. The so-called gallop rhythm of the heart—a doubling of the second sound—asserted by Potain to be characteristic of renal cirrhosis, has been recently shown by Fräntzel to occur in other affections also.

The relation between renal cirrhosis and the coincident cardiac hypertrophy has been the subject of much dispute and investigation for many years past. By some it has been assumed that the cirrhosis was the primary affection, and that in consequence of the occlusion of numerous blood-vessels in the kidneys, the blood-pressure was increased and the hy-

pertrophy of the heart induced. Others have maintained that the general disease of the arteries, in other organs as well as the kidneys, was the primary difficulty and cause of cardiac enlargement. It would exceed our limits to recapitulate the observations, clinical and experimental, which have been adduced to support each of these hypotheses. Notwithstanding the reported demonstration that, by transient ligature of the renal arteries in dogs and rabbits, chronic interstitial nephritis and secondary cardiac hypertrophy have been induced (Grawitz, Israel, Lewinski, denied by Zander), the weight of evidence indicates that the original affection is a disease of arteries throughout the body, as a consequence of which blood-pressure is increased and cardiac hypertrophy induced. Whether or not this general disease of the arteries is a result of the accumulation in the blood of materials which should be eliminated by the kidney, is undetermined.

The diagnosis of the renal participation in the general disease is made by the characteristic appearances of the urine. The quantity excreted is increased sometimes enormously (Bartels records a daily excretion of 12,000 c.c.); from 2,000 to 4,000 c.c. is a frequent daily amount. In many cases the quantity excreted during the night is greater than that passed by day, and the patient's rest is disturbed by frequent calls to urinate. The urine is in consequence of its dilution of unusually light color, often with a greenish tinge; it is of acid reaction, unless rendered otherwise by medication. The specific gravity is less than normal, usually about 1.010, varying with the amount excreted; it is higher by day than at night, corresponding to the lessened excretion during the day. It is remarkable that during intercurrent febrile attacks, the specific gravity remains, contrary to the usual rule, below normal; an observation of this sort should direct attention to the possibility of renal cirrhosis.

The diminution in specific gravity seems to be dependent simply upon the polyuria and not upon a decrease in the amount of solids excreted; for, until the latter period of the disease, the amount of urea and salts remains at or near the normal figure. The phosphates are, however, retained to a considerable extent, and Fleischer observed that phosphoric acid administered to a subject of renal cirrhosis is not excreted as completely as by healthy kidneys. At a later period of the disease there is a retention of all the solid constituents, including urea; indeed, a somewhat diminished excretion of urea is often observed during the earlier course of the disease. Fleischer found that a patient suffering from this affection excreted less urea than a healthy person, when both were kept upon the same diet.

The urine usually contains albumen, though this may be absent for days or weeks at a time—an absence which sometimes misleads the physician who is accustomed to regard non-albuminous urine as proof of the integrity of the kidney. The proportion of albumen is always small, usually not more than 0.1 or 0.2 per cent.; yet such a percentage in so large a quantity amounts to several (three to six) grammes per day. It is noticeable that the urine excreted during the night is more frequently free from albumen than that evacuated during the day, a fact to be borne in mind in determining the nature of the complaint; if the morning urine only be examined, it may be found non-albuminous, yet later in the day it contains albumen. Physical exertion or mental excitement usually causes an increased excretion of albumen; and uræmic attacks or outbreaks of gout are preceded and followed for some time by increased albuminuria.

The existence of renal cirrhosis is not excluded by the absence of albumen even upon repeated examinations, since a few cases are on record in which no albumen was at any time found in the urine, although the section re-

vealed unmistakable cirrhosis and the symptoms other than albuminuria were characteristic. Indeed, Schuchardt records a carefully observed case in which the urine was always normal in every respect until just before death ; the autopsy revealed pronounced atrophy and inflammation of the kidney.

But little or no sediment is macroscopically visible. Upon microscopical examination, however, there are found tube-casts, chiefly hyaline, but occasionally granular (Fig. 12). Now and then a cast studded with cells from the urinary tubules, or with uric acid, urates and oxalate of calcium, is observed. During transient exacerbations of the renal affection, and after uræmic or gouty attacks, a considerable number of epithelial casts and renal epithelial cells may be found in the urine. Leucocytes, and sometimes red corpuscles, are present in small number.

Fig. 12.—Sediment from Renal Cirrhosis.

Course and Duration.—The general appearance of the patient often betrays no especial abnormality, while at other times the skin is unusually pale, dry, and harsh. A frequent symptom is persistent and annoying itching, which is present day and night, and drives the patient to desperation. In other cases obstinate eczema is developed, which yields but slowly to treatment and breaks out afresh without provocation. The general nutrition usually remains unimpaired, though emaciation is sometimes observed, and the individual may complain of corresponding loss of strength. All these symptoms occur, however, less frequently and with less prominence than during the course of chronic parenchymatous nephritis.

The disease may last for many years even after its discovery, and has usually existed for a considerable time before the diagnosis is made or its nature even suspected. On the other hand the life of the patient may be cut short by any one of the numerous complications so often observed, among them uræmia, cerebral hemorrhage, inflammation of the lungs or serous membranes, catarrh of the intestinal tract, or œdema of the lungs or glottis. Recovery from pronounced and undoubted cirrhosis of the kidney has never as yet been reported.

Among the most characteristic, though by no means most constant, symptoms observed are the changes which occur in the retina. These may be suspected from the impairment of vision of which the patient complains ; amblyopia, dimness of vision, muscæ volitantes, and other distortions of the sight occur. An occasional incident is sudden and complete blindness affecting one eye and disappearing in the course of a few days ; in other instances both eyes are simultaneously affected, apparently from no anatomical change, but from incipient uræmia.

In the retina there are observed yellow spots, which often surround the

optic papilla, but more frequently are located in and around the yellow spot, where they are arranged as rays radiating from this point. In other cases the spots have no definite topographical relations either to the papilla or to the macula lutea. These spots are occasioned partly by fatty degeneration in the granular layers of the retina, partly by hypertrophy of the nerve-fibres, both changes apparently resulting from pathological changes of the retinal vessels. Aside from this so-called "retinitis albuminurica" there is observed, in cases of renal cirrhosis, the appearance known as "choked disk," the result of venous congestion. All of these abnormalities of the retina may subside when due to renal cirrhosis; the last named, however, occasionally results in atrophy of the disk. Apoplexy of the retina, as well as of the brain, is often found in these cases of renal disease.

Failure of the hypertrophied heart from fatty degeneration, or acute intercurrent disease, causes a change in the clinical picture: the urine becomes less profuse, the specific gravity somewhat higher, the percentage of albumen is increased, digestive disturbances are aggravated, perhaps slight dropsy becomes apparent, and uræmic symptoms threaten. Secondary dilatation of the heart, causing dyspnœa, asthma, palpitation, etc., may follow.

Diagnosis.—The difficulties of diagnosis arise not from the resemblance of the symptoms to those produced by other affections of the kidney, but from the fact that these symptoms may be exhibited during a long period chiefly or entirely by other organs. After the polyuria, albuminuria, and tension of the pulse are recognized, the diagnosis is easy. A systematic examination of the urine in every case of disease would often reveal an unsuspected renal cirrhosis. It is readily distinguished from acute and chronic parenchymatous nephritis by the profuse excretion of urine, its clear color, low specific gravity, slight sediment, and small percentage of albumen; the absence of dropsy, the presence of lesions in the heart, arteries, nervous system, and eye are additional factors in making up a diagnosis. During acute exacerbation the urine may present the changes characteristic of acute inflammatory process and dropsy may be present; indeed, there may be an acute nephritis engrafted upon an undiscovered renal cirrhosis. After the subsidence of this, however, the features of the latter affection persist. In the absence of cardiac hypertrophy—either from temporary cause or from a complication with amyloid degeneration—the urine may be diminished and the percentage of albumen increased; indeed, dropsy may exist in slight degree.

The distinction from simple amyloid degeneration of the kidney is rarely difficult; for in the latter condition the urine is less abundant and contains a greater percentage of albumen; there is no evidence of cardiac hypertrophy or changes in the retina, while there is usually enlargement of the spleen and liver; the history, too, indicates the origin and nature of the affection. The complication of renal cirrhosis with amyloid degeneration produces a puzzling condition which cannot always be recognized; for there may be no changes in the heart or arteries, while the other symptoms indicate interstitial nephritis. The polyuria may lead to a diagnosis of diabetes insipidus; indeed, it is probable that this mistake is not rare. Careful consideration of the other features in the case will easily lead to a correct distinction between the two.

Senile atrophy of the kidney, though perhaps indistinguishable from renal cirrhosis by post-mortem inspection of the organ, is easily distinguished clinically; for this purely senile atrophy is accompanied with a diminished rather than an increased excretion of urine; there is no cardiac

hypertrophy nor increased arterial tension; albuminuria is rare and uræmia absent.

In his ardent search after latent renal cirrhosis, the physician must guard against the temptation to make this diagnosis in cases of intermittent or persistent albuminuria when the other symptoms are absent; for such albuminuria may exist without any form of renal disease, and its occurrence is usually preceded by symptoms in the circulatory and digestive organs at least which explain the significance of the albumen. The coincidence of increased arterial tension, persistent headache, dyspepsia or diarrhœa with albuminuria, should be regarded as strongly suggestive of renal cirrhosis and as ground for maintaining a constant supervision of the patient. Yet it must be admitted that, even with the most careful attention to all diagnostic points, cases occur in which the presence or absence of renal cirrhosis can be determined only after considerable time has elapsed. It is certain that intermittent or constant albuminuria, even associated with a decided increase of vascular tension, may last for some months and then disappear permanently. Possibly such cases are really instances of incipient or localized renal cirrhosis, or the albuminuria may originate in conditions independent of the kidney. Such cases must be distinguished from those of genuine and undoubted renal cirrhosis in which remissions lasting, perhaps, weeks or months occur, during which periods no albumen is found in the urine.

Prognosis.—No instance of recovery from pronounced and undoubted renal cirrhosis is yet recorded; yet the affection is not incompatible with many years of comparatively good health. Instances are known in which patients have survived fifteen and even twenty years after the detection of the renal affection, and the physical and mental powers are frequently retained without serious impairment for six or eight years. Yet the condition is liable to so many complications, often fatal, that no security to life is afforded. Cerebral hemorrhage, uræmia, œdema of the lungs and glottis, may occur suddenly in the midst of apparent health.

Treatment.—The object of treatment is in the majority of cases merely the protection of the patient from the consequences of the disease; for the nature of the primary affection is often undiscoverable. The attempt to arrest the increase of connective tissue in the kidney by remedies addressed to that organ must be, and as a matter of fact is, futile, since this cirrhosis is merely one result of a constitutional condition. In those cases in which a definite cause can be assumed, such as syphilis or lead poisoning, the administration of remedies known to counteract these specific influences is occasionally followed by success. The iodide of potassium with or without the bichloride of mercury has been known to arrest the morbid changes in the kidneys and arteries, and thus to restore the individual to comparative health. Since, moreover, a syphilitic taint may lurk unsuspected and undiscovered, the iodides may be in almost every case administered with propriety.

In most instances, even in some of undoubted syphilitic history, these remedies produce no appreciable effect in arresting or even retarding the morbid process. Certain other drugs have seemed at times beneficial; thus Bartholow recommends the chloride of gold, and says, "Better results even" (than the iodides), "the author believes, are procured from the careful and persistent administration of the chloride of gold or of gold and sodium." "These remedies, intended to arrest the hyperplasia of the connective tissue, should be prescribed with a definite relation to the presumed cause—iodide of potassium and bichloride of mercury, in those with a

syphilitic history; iodide of potassium in those poisoned by lead; and chloride of gold and arsenic in those cases of unknown origin."

Aside from such measures of doubtful utility, nothing can be done by drugs to check the increase of connective tissue in the kidney or the degeneration and thickening of the arteries. The treatment consists simply in efforts to maintain the nutrition of the patient, and to avoid the numerous complications which beset him in the course of the disease.

A judicious diet constitutes a most important feature of the treatment. The food should be nutritious and plentiful, but contain no more nitrogenous matter than is necessary for health. The diet may consist largely of milk, eggs, and vegetables; fat meat is permissible, but lean meat should be taken sparingly. Wines and liquors of all kinds should be avoided unless required for purposes of stimulation. These dietetic principles, though generally applicable, must not be regarded as inflexible rules; individual wants and peculiarities often require the use of beer or light wines; the obstinate dyspepsia which so annoys and debilitates the person, may be relieved by these when other measures fail. Careful observation of the effects upon the general condition and the state of the urine must constitute a considerable factor in prescribing the diet.

The body should be warmly clothed, the skin being protected by wool in all seasons; the greatest care should be taken to avoid exposure to cold and moisture, since simple wetting of the feet may precipitate a uræmic attack. Residence in a warm, dry, and uniform climate has sometimes seemed to retard or even to arrest the disease.

Rest of body and mind is conducive to the welfare of the patient and the avoidance of complications. Prolonged mental exertion and intense excitement may, like excessive bodily exercise, provoke rapid progress of the disease or the outbreak of complications. It is not desirable to confine the patient to bed or to forbid ample exercise, except during those periods when the heart is especially feeble. It is only necessary to avoid excess of bodily and mental activity which a healthy man may undertake with impunity; for the subject of renal cirrhosis is an invalid, however objectionable and unfounded this idea may seem to him.

The loss of albumen can be readily compensated through the food, and does not constitute an important factor of the complaint.

Among drugs, iron, quinine, and mineral acids may be administered almost continually. After a long course of iron, headache and gastric disturbance are indications for its discontinuance; it should be renewed after an interval of rest. Some experimentation may be necessary to discover the most suitable form for the administration of iron; the most generally useful is Basham's mixture, though the citrate of iron and quinine may be substituted for a time with advantage.

Some of the complications which render this disease so dangerous arise from hypertrophy of the heart and degeneration of the vascular walls. We are acquainted with no means for arresting either of these processes; in fact, an attempt to prevent the cardiac hypertrophy would be unjustifiable and, if successful, disastrous, since the continued activity of the kidney can be maintained only by increased effort on the part of the heart. The only safety against complications on the part of the circulatory organs lies in the avoidance of physical and mental exertion and excitement. At a later period it may become necessary to stimulate rather than quiet the heart; for after a time the compensatory hypertrophy, which at first enables the kidneys to excrete the usual amount of solids, fails to keep pace with the increasing degeneration of these organs, or gives place to

dilatation or fatty degeneration of the heart-muscle. This failure of the heart is indicated by the diminished excretion of urine and by the increased percentage of albumen; it calls for cardiac stimulants, especially digitalis.

A uræmic attack may be expected, if the amount of urine is decidedly decreased. Many premonitory signs may occur; such are muscular twitchings, sudden failure of sight, double vision, intense occipital pain, cerebral excitement, insomnia, etc. The occurrence of any of these should lead to an immediate examination of the urine; if the amount is decreased, the albumen increased, or the solids lessened, the skin and bowels should be stimulated without waiting for pronounced uræmic symptoms. Purgatives and a hot bath or wet-pack often suffice in the earlier stages of the disease; at a later period it is necessary to employ pilocarpine subcutaneously, as already directed. The inhalation of chloroform or amyl nitrite, chloral by the mouth or rectum, or a hypodermic injection of morphine in large doses, as practised by Loomis, may be required to control the convulsions.

In the treatment of the numerous complications which arise in the course of the disease—dyspepsia, diarrhœa, inflammation of serous membranes, asthma, etc.—one fact is to be borne in mind, namely, that since the renal activity is impaired, the elimination of drugs is less rapid and complete than in other conditions; hence powerful remedies, especially narcotics, must be employed with the greatest caution. Some of these complications, especially those manifested by the digestive tract, may be averted and abated by the daily use of warm baths, whereby the excretory activity of the skin is favored. The various troubles originating in cerebral congestion may be to some extent avoided by securing regular evacuations from the bowels; in case of emergency such congestion may require venesection, though depressing measures are in general contraindicated.

Fatty Degeneration of the Kidney.

This condition is usually associated with fatty degeneration of other organs, and is found in various anæmic and cachectic states—consumption, scrofula, pernicious anæmia after profuse hemorrhage, chronic suppuration, etc. It is observed as an accompaniment of acute febrile affections, especially the infectious diseases; it may result from extensive disease or injury of the skin, such as burns, and may follow the prolonged or excessive use of various toxic agents, such as phosphorus, arsenic, etc.

Fatty degeneration is frequent in old age without other apparent cause; it is then usually associated with a similar condition of the liver and of the heart.

This state of the kidney is not usually recognizable during life. It is often accompanied by a slight albuminuria, and it is said that in a few cases fat has collected in appreciable quantity so as to make a slight scum upon the surface of the urine. Since the fatty kidney performs fairly well its functions, and since other organs similarly affected (especially the heart) are apt to fail earlier than the kidney, the condition of the latter constitutes no imperative requirement for medication; moreover, treatment offers a hope of success only when it can be employed for the removal of a known cause, such as anæmia or phosphorus poisoning.

Suppurative Nephritis.

This form of renal inflammation differs from Bright's disease both anatomically and etiologically; it is not a diffuse but a circumscribed inflammation.

Etiology.—It may result either from direct extension of a previous inflammation, or from metastasis, the transfer of inflammatory elements from other organs by means of the blood; also from direct mechanical injury to the kidney.

Suppurative inflammation by extension of the inflammatory process is most frequent after cystitis and pyelitis; it so frequently follows the last-named affection that it is often termed pyelo-nephritis. This name is properly applied only to cases of suppuration in the kidney following pyelitis, and ignores instances in which the disease is produced by other influences. It may also be induced by the extension of a perinephritic inflammation, the result of wounds or injury in the renal region.

Concretions in the substance of the kidney, infectious emboli from distant foci of inflammation, are occasional causes. It is possible that certain acrid diuretics, such as cantharides, copaiba, and turpentine, may by simple contact arouse suppurative inflammation in the pelvis and the kidney.

Suppurative nephritis of metastatic origin may occur during any of the septic diseases; it is not unusual in pyæmia, septicæmia, puerperal fever; but occurs with especial frequency in cases of ulcerous endocarditis. Yet it may also result from local inflammations of septic origin without general infection; Böttcher has described a remarkable case of pulmonary abscess, with secondary abscess in the kidney; in the latter were found elastic fibres from the lung, demonstrating the origin of the local renal inflammation in an embolus from the lung.

The extension of inflammation from the tissues surrounding the kidney or from the lower urinary channels is the most frequent cause of suppurative nephritis. Thus it occurs as the result of psoas abscess, tuberculosis of the vertebræ, abscess of the liver or of the spleen; more frequently from inflammation in the bladder or the pelvis of the kidney; and these may be in turn induced by most diverse pathological processes and operative procedures in any portion of the urinary channel. Thus the presence of stones in the bladder or in the pelvis of the kidney, occlusion of the ureter by renal calculi, hypertrophy of the prostate are sometimes followed by suppurative nephritis; the numerous conditions of the bladder and ureter which require operative interference are extremely productive of renal suppuration. Paresis of the bladder as it occurs during disease of the spinal cord and in old age from hypertrophy of the prostate, stricture of the urethra, phimosis, frequently call for surgical interference, which is apt to be followed by suppurative nephritis. In previous pages attention has been already directed to the condition known as "negative pressure"—that condition in which, in consequence of obstruction to the evacuation of the urine, distention and increased pressure in the urinary channels behind the obstruction occur. The sudden relief of this increased pressure by the removal of the previously existing obstruction is followed by intense congestion and inflammation of the previously distended channels; hence it happens that operations for phimosis, division or divulsion of a narrow stricture, the evacuation of the bladder by lithotomy or lithotrity, even the introduction of a catheter, may be sufficient to

induce this inflammatory process. The frequency of suppurative nephritis after these surgical procedures has caused the adoption of the name "surgical kidney" to designate this affection.

It is worthy of note that although the inflammatory process usually involves the bladder before proceeding to the kidney, yet in some cases severe and even fatal inflammation of the latter organ occurs without pronounced inflammation of the lower urinary passages. In some few cases the formation of concretions in the substance of the kidney itself has been followed by suppuration in the organ; renal abscesses are occasionally found in the subjects of diabetes. Rare cases are recorded in which suppurative nephritis appears to have been the direct result of injury, such as a blow or wound over the kidney; in such instances the renal inflammation is usually subsequent and apparently secondary to suppuration in the perinephritic tissue. In still other cases no cause can be assigned for the origin of the disease.

Morbid Anatomy.—This varies with the stage of the affection. The size of the organ may not be abnormal, but its surface and parenchyma are studded with grayish points, often round, at times linear, and varying in size from the limit of the visible upward. At a later stage abscesses are seen; indeed, the entire organ can be transformed into a mass of pus from the coalescence of the initial abscesses.

The capsule of the kidney is thickened and adherent, and at times perforated by openings which may lead into any of the neighboring organs—colon, liver, lungs, small intestine, stomach, into the peritoneal cavity or even through the abdominal wall; in other cases the pus does not extend beyond the mass of fat which envelops the kidney, but this may be so enlarged and distended as to constitute an extensive tumor readily perceptible through the abdominal wall. In many instances the pus undergoes cheesy degeneration, which may be followed by calcification, at least in spots. Sometimes the cheesy mass is more or less completely absorbed and replaced by a growth of connective tissue, which results in contraction and deformity of the kidney.

The extent and subsequent changes depend largely upon the cause of the suppuration; when due to inflammation of the lower urinary passages, concretions, or traumatic influence, the inflammation is often limited to one kidney; if caused by metastatic deposits, on the other hand, both kidneys are usually affected.

Upon microscopic examination a considerable portion of the renal substance may be found of normal appearance; in the immediate vicinity of the abscesses there are evidences of acute inflammatory condition. Upon examining a miliary abscess there will always be found, in cases of metastatic origin, and often in those resulting from inflammation of the bladder, masses of micrococci in the walls of the abscess and mingled with the pus. If the observer be fortunate enough to have included in his section an incipient abscess, so small that the contents do not fall out in the preparation of the object, he will find that the centre is composed of a mass of these spherical bacteria, usually constituting an embolus in a minute blood-vessel—one of the intertubular capillaries or a capillary loop in a glomerulus. Occasionally such an embolus is found before suppuration has occurred; the mass of micrococci is surrounded by a zone of inflamed renal tissue, the epithelial cells being swollen and granular; a few scattered leucocytes are observed, indicating the beginning of abscess formation.

In metastatic suppurative nephritis the masses of micrococci are often

observed as grayish stripes, which are found to be blood-vessels filled with these organisms. In the cases which arise by extension from the bladder and ureter, the bacteria are observed as plugs filling the urinary tubules.

The pelvis of the kidney usually exhibits morbid appearances; it is dilated, the mucous membrane is swollen, perhaps eroded and coated with thick mucus and pus. The ureter is the seat of similar changes. Calculi or masses of pus are found in the pelvis and in the dilated ureter.

Symptoms.—The symptoms vary according as the pelvis of the kidney is or is not extensively implicated in the inflammatory process, the symptoms of pyelo-nephritis being somewhat different from those of a suppurative inflammation limited to the kidney alone.

In the latter case the recognition of the affection is ordinarily difficult or impossible. So long as the pus is produced as miliary abscesses only—a condition usually consequent upon ulcerous endocarditis or other septic process—no symptoms are observed which direct attention especially to the kidney; there may be a chill and fever, but these occur as a part of the primary affection. The collection of pus in larger quantities is usually followed by the familiar symptoms of such condition—repeated chills, remittent fever, profuse perspiration, emaciation, and diarrhœa; while these symptoms indicate suppuration in some internal organ, they do not locate the process in the kidney.

Sooner or later various symptoms may be manifested which indicate that the renal tissue is the seat of a morbid process. Pain and tenderness upon pressure in the region of the kidney are frequent, though by no means constant phenomena. The pain is most severe in the loin, but radiates toward the navel, into the groin and down the thigh; contraction of the cremaster is often observed. Limitation in the movement of the lower extremity on the corresponding side is an occasional symptom, more frequent after the inflammation has extended to the perinephritic tissue or the pelvis. Sometimes the patient can rest easily only on the opposite side; or he may find least discomfort when he lies upon the abdomen. The pain is often intermittent or remittent in character, and is sometimes increased to an agonizing degree.

A tumor may be observed when the suppuration has become extensive. This is rarely seen until the pus has broken into the pelvis of the kidney. The distinction of this from other tumors which may occupy the same locality is by no means easy. The extent and location of these tumors may vary considerably, and they present no peculiar and characteristic features. Distinct fluctuation is not frequent. Abscess of the kidney can sometimes be distinguished from perinephritic abscess by the fact that the former is less profuse and is susceptible of more definite limitation; from tumors of the spleen and liver by the absence of movement during respiration, and by palpation, since the fingers can be inserted between the tumor and the spleen or liver.

The urine furnishes some information; the most constant abnormal ingredient is blood, which may be present in such amount as to give the urine a smoky color, or in such small quantity as to be recognizable only by the microscope. Pus may be absent until an abscess of considerable size has opened into the pelvis; and even if present, the source of the pus cannot be definitely located, unless accompanied by other elements, such as fragments of renal tissue. Even though there exist a tumor in the renal region, one cannot be sure that pus found in the urine proceeds from the kidney substance or renal pelvis; thus Ogle observed a case in which a large abscess formed behind the left kidney from caries of the

second lumbar vertebræ; the pus burrowed downward and broke into the bladder.

The urine always contains albumen, which may be no greater in amount than is naturally furnished by the pus and blood present; in pyelo-nephritis, on the other hand, the amount of albumen often exceeds that which would correspond to the pus, and may be considerable even when there is but little sediment. Tube-casts are often found, usually only the hyaline and granular forms, though occasionally an epithelial cast or one composed wholly of bacteria is discoverd.

In a few cases small portions of renal tissue have been expelled with the urine; Wiederhold saw such a piece as large as a pigeon's egg and containing distinct urinary tubules. The discharge of such pieces locates definitely the seat of the suppuration, but is so rarely observed as to be practically unavailable.

So soon as the pus has escaped into the perinephritic tissue, various additional symptoms may be manifested. The pus may burrow into the skin, which becomes swollen, œdematous, and doughy; or it may perforate the intestine, causing purulent stools; into the peritoneum, etc; indeed the case then becomes one of perinephritic inflammation. In a few cases paralysis of one or both legs has been seen, apparently the result of an ascending neuritis, originating in or around the kidney and extending to the spinal cord.

In most cases of suppuration in the kidney the pelvis becomes sooner or later involved in the morbid process. In many other cases the inflammation has extended from the pelvis to the kidney. A suppurative nephritis is, therefore, either from the beginning or at a later stage, a pyelo-nephritis; the inclusion of the pelvis in the morbid condition renders the diagnosis less difficult.

Pyelitis and Pyelo-nephritis.

In every case of pronounced pyelitis the inflammatory process extends to the renal papillæ which project into the pelvis; anatomically, therefore, there may be no grounds for distinguishing a pyelitis from pyelo-nephritis, but clinically such distinction is quite important; an inflammation of the pelvis implicating only the papillary portion of the kidney is distinct in symptomatology, prognosis, and treatment from one in which the inflammation extends to the deeper portions of the organ.

Pyelitis may be a primary or secondary affection, and may pursue an acute or chronic course; it is usually chronic and secondary, and, therefore, like cystitis, a *symptom* of other morbid conditions. Its course, duration, and termination are determined largely by the affection which produces it.

The inflammation is at first catarrhal, but may rapidly become purulent or hemorrhagic; croupous and diphtheritic inflammations of this as of other mucous membranes are observed in the course of certain infectious diseases. Yet diphtheritic pyelitis is far less frequent than the report of autopsies indicates; ulceration and necrosis of the mucous membrane is not necessarily an evidence of diphtheritic inflammation, since it is a frequent feature of simple purulent pyelitis. Some blood escapes into the pelvis during the ordinary catarrhal and purulent inflammation; the quantity is much greater in those constitutional conditions which include a tendency to extravasations in the mucous membranes generally, presumably from abnormal conditions of the blood or blood-vessels—scurvy, per-

nicious anæmia, hemorrhagic small-pox. Ollivier has described under the name *pyelo-nephrite hemato-fibrineuse* a hemorrhagic form of pyelitis which is peculiar to old age, and is apparently a local manifestation of general arterial disease; there exists a sclerosis of the arteries and consequent tendency to the formation of aneurisms. The rupture of miliary aneurisms in the pelvic mucous membrane is followed by the formation of clots, which are supposed to produce an inflammation by mechanical irritation.

Etiology.—Simple retention of urine, due to some mechanical impediment in the urinary channel, is sufficient to produce pyelitis; this inflammation is therefore a frequent sequence of urethral stricture, prostatic hypertrophy, vesical calculi or neoplasms, paresis of the bladder, tumors (especially cancerous) of the womb, pregnancy, etc. The ammoniacal decomposition of the urine is not essential for the production of pyelitis, though the inflammation is much aggravated when such decomposition occurs. So long as the surgeon refrains from instrumental interference in the bladder and urethra, the urine retained in the pelvis and bladder rarely undergoes the ammoniacal change; and if such instrumental interference—the introduction of a catheter, dilatation of a stricture, removal of a vesical stone, etc.—be intelligently performed, but little if any aggravation of either pyelitis or cystitis need occur. When, however, such operation is performed without reference to the condition of the bladder, an aggravation of an existing pyelitis, usually with ammoniacal fermentation of the retained urine, is the regular result (see Urethral Fever).

Pyelitis also arises as a simple extension of inflammation, most frequently in the bladder, but occasionally in the kidney or perinephritic tissue. Cystitis induced by mechanical irritation of a stone, even without instrumental interference, usually produces pyelitis also—a complication which materially lessens the patient's chances for recovery after operation; hence the earliest possible removal of the stone is desirable.

It is a familiar observation that pyelitis is a frequent affection during pregnancy as well as in the puerperal state; also after gynecological operations. Different etiological factors are responsible for various cases. There can be no doubt that the pyelitis which originates during pregnancy is frequently produced by simple retention of urine in consequence of compression of the ureters by the enlarged uterus; while the cases which arise after delivery are produced partly by the extension of pelvic inflammations and partly by the sudden evacuation of the urine previously retained in the distended pelvis; probably many of the so-called "idiopathic" cases of puerperal pyelitis originate in this way. It is worthy of note that even when pyelitis seems unmistakably to have been produced by an extension of vesical inflammation, the mucous membrane of the intervening ureter may exhibit little or no abnormality.

The acute and severe infectious diseases may produce an inflammation of the renal pelvis as of other mucous membranes; among these are cholera, small-pox, diphtheria, and the septic diseases; diabetes and the acute gastro-enteritis of nurslings are also frequently complicated with pyelitis. The inflammation which occurs during the acute infectious diseases is often croupous or diphtheritic; it possesses comparatively little clinical significance because it is often overlooked, and because its importance is overshadowed by the constitutional affection.

Foreign bodies in the pelvis—blood-clots, fragments of tissue, parasites—arouse pyelitis either by direct mechanical irritation or by serving as nuclei for the formation of renal calculi; calculous pyelitis is doubtless the most frequent of all forms.

The administration of certain irritant drugs—cantharides, balsams, turpentine, etc.—is credited with the responsibility for certain (doubtless rare) cases of pyelitis, usually of the croupous variety. Neoplasms may also originate the disease; it is a regular feature of cancer or tuberculosis of the pelvis or kidney.

In a certain number of cases no definite cause can be assigned; hence they are referred to "taking cold."

The implication of the kidney may consist merely in a catarrh of the straight tubules, or may amount to a suppurative nephritis; the extent of the renal implication is determined chiefly by the cause. Suppurative nephritis is especially frequent in those cases produced by inflammation and operation in the lower portion of the urinary channel.

Morbid Anatomy.—The morbid appearances vary according to the stage and degree of the inflammation; they are in general those of catarrh of a mucous surface. Ulceration may occur even when no foreign bodies are present. In cases of chronic pyelitis capillary new formations project into the cavity, covered with a deposit of urates and phosphates. Dilatation of the pelvis is usual in chronic and frequent in acute pyelitis; it seems to result from temporary occlusion of the ureter, either by simple swelling of the mucous membrane, or by plugs of mucus, pus, and blood. Hydronephrosis and pyonephrosis in slight degree may occur; indeed, extreme dilatation of the pelvis and consequent atrophy of the renal tissue is a possible result. Masses of cheesy pus mixed with urinary salts are commonly found.

When the kidney also is inflamed, it presents the morbid appearances of suppurative nephritis or of a diffuse inflammation, at first affecting the pyramids and subsequently involving the cortical portion; chronic interstitial nephritis, and even complete atrophy of the kidney may follow the occlusion of the ureter and pelvis by caseation and calcification of pus.

Symptoms.—Simple catarrhal pyelitis often exists undetected during life, partly because it may occur without pronounced subjective symptoms, and partly because the objective symptoms are chiefly to be discovered by an examination of the urine—which is not always made; in many cases, too, the primary lesion is of such a nature as to obliterate the distinctive features of pyelitis; such is the case when it results from chronic cystitis, puerperal affections, operations upon the pelvic viscera, etc.

Acute pyelitis may be ushered in with severe chill and fever, perhaps vomiting also; acute pain over the kidney and radiating into the groin may be experienced. Such cases are comparatively rare, and are distinctly observed chiefly during pregnancy and the puerperal state, and as a complication of gonorrhœa.

In chronic cases there may be no distinctive symptoms aside from the characters of the urine. When associated, as it frequently is, with cystitis, frequent and somewhat painful urination may be the subject of complaint, the patient voiding but little urine at a time. This symptom is also seen without inflammation of the bladder, when the pyelitis is of calculous origin; and because associated with pus and blood in the urine, it may mislead the physician into a diagnosis of cystitis.

Pain in the loin is a frequent though not constant symptom; it may be of a dull aching character and occasionally sharp and severe, suggestive of renal colic. In the latter case it is felt along the course of the ureter, in the genitals, perhaps in the thigh. This pain seems to be caused largely by transient hydronephrosis; it varies in severity with the freedom with which the urine is discharged, being greater when temporary obstruction

and oliguria exist. It may be felt over both kidneys, even when the inflammation exists on one side only. There is frequently some tenderness upon pressure over the kidney.

Variations in the quantity of pus discharged with the urine are often quite characteristic of this affection. If the ureter of the affected side be obstructed by pus, mucus, concretions, etc., the pus disappears from the urine evacuated, since this is furnished by the healthy kidney; after a time the obstruction is overcome and a sudden discharge of pus with the urine is noticed. These phenomena are accompanied by corresponding symptoms; during the excretion of clear urine—while the opposite ureter is obstructed—constantly increasing pain and tenderness on the affected side, perhaps a chill, fever, and vomiting are noticed. The copious evacuation of turbid urine occasions an immediate subsidence of these symptoms.

In occasional cases the obstruction to the ureter produces such a degree of hydronephrosis as to cause a perceptible swelling in the region of the kidney. The dimensions of this tumor vary with the other symptoms; it increases in size when the urine becomes clear and the pain severe, and diminishes when the pus is again discharged and the pain subsides.

The characters of the urine vary with the cause and complications of the pelvic inflammation. If there be no ammoniacal decomposition in the lower urinary channels, the urine is acid, pale, and in a pronounced case has a low specific gravity, due to the fact that the quantity excreted in twenty-four hours is much increased (even to twice the usual amount). This polyuria is especially great in cases where chronic inflammation and cirrhosis of the kidney have supervened. It may be so pronounced as to mislead into a diagnosis of diabetes insipidus, a mistake to which Oppolzer called attention.

Fig. 13.—Sediment from Acute Pyelitis; Epithelial Cells from the Pelvis, Leucocytes, and Blood-corpuscles.

The sediment contains pus and blood, the amount varying at different times even in the same case (Fig. 13). The pus-corpuscles are often massed into plugs or threads, similar to those produced in the urethra during gleet. Numerous epithelial cells are seen, and it has been asserted that the locality of the suppuration can be recognized by the appearance of these accompanying cells. Now, it is true that in pyelitis short columnar cells with large nuclei, adherent in masses, are especially frequent; but neither the arrangement nor the form of the cells is characteristic of pyelitis; for these, as well as the caudate and bipolar cells often considered characteristic of this affection, are also produced in the bladder and urethra. It is unsafe, if not impossible, to base a diagnosis of pyelitis upon the epithelial cells found in the sediment.

So soon as the inflammation has extended to the tubules of the kidney (and even before, if there be decided fever) hyaline casts appear in the sediment; the presence of granular casts may be regarded as indicating the implication of the kidney, *i.e.*, pyelo-nephritis. In cases of cysto-

pyelitis, casts composed of or thickly covered with bacteria are seen (Fig. 14).

The urine always contains albumen, even though but little pus be present; the extension of the inflammation to the kidney is indicated by a still greater percentage of albumen. This excess of albumen over the quantity which can be expected from the amount of pus present is, therefore, in afebrile cases, an important item in recognizing the implication of the kidney; yet it is less decisive than the evidence furnished by the microscope.

FIG. 14.—Sediment from Pyelo-nephritis; Casts studded with Bacteria, Epithelium from the Pelvis, Leucocytes, Blood-corpuscles and scattered Bacteria (Fürbringer).

The kidney becomes the seat either of a diffuse inflammation sometimes terminating in cirrhosis, or of a suppurative nephritis. The latter is the rule when cystitis also exists—therefore, after injudicious use of the catheter or instruments—and is especially frequent in old men at the commencement of "catheter life." This complication is marked by remittent fever, frequent chills, somnolence, a small and rapid pulse; in short, the features of subacute uræmia or pyæmia. In old men the fever and constitutional disturbance may be slight, and the source of the difficulty overlooked.

The pyelitis of the puerperal state is usually indicated by pronounced symptoms which cannot be overlooked nor misinterpreted. Its onset is marked by chill, fever, and pain over one or both loins; there is decided tenderness in this locality. The pain is acute and may simulate renal colic. The urine is acid and contains a decided amount of albumen and some pus.

An acute pyelitis is occasionally seen during or immediately after gonorrhœa; it is secondary to cystitis and is marked by pronounced symptoms —chill, fever, severe pain in the loin, occasionally vomiting and intense headache. In the Venereal Clinic at Vienna, Finger saw this complication twelve times among four hundred and ninety-five cases. It is usually of brief duration; is favored by bodily exertion and indulgence in alcoholics.

In a few cases the subsidence of the pyelitis has been accompanied by the disappearance of both cystitis and gonorrhœa. In a few rare cases (Vidal, Rosenstein) severe pyelo-nephritis has originated during the course of gonorrhœa and has become chronic.

Diagnosis.—A pronounced case of acute pyelitis is as a rule easily recognized by the symptoms already mentioned.

Chronic pyelitis, on the other hand, is frequently for a long time overlooked; and when pus is discovered in the urine, great care is necessary in distinguishing between pyelitis and cystitis. The reaction of the urine does not serve to differentiate, since it may be acid or alkaline in either of the two affections; the form of the epithelial cells and the percentage of albumen afford a probability but not a certainty in diagnosis. The appearance of hyaline, granular, and bacterial casts with the pus makes the diagnosis quite positive. In the absence of these elements the existence and location of pain are important features. Pyelitis is frequently painless; the pain if felt is often referred to the loins. Cystitis is rarely painless, and the pain is felt behind the symphysis and in the perineum. These are, however, by no means absolute rules, since the pain of pyelitis is sometimes referred to the bladder-neck and is accompanied with frequency of micturition.

When secondary to cystitis, pyelitis can be recognized with certainty only by the pain and tenderness in the region of the kidney, and by the increased fever. So soon as the kidney also is involved, cylinders will be found in the sediment; chills, fever, vomiting, etc., may occur. As already stated, pyelitis may be expected as a sequence of chronic cystitis; its onset is hastened by injudicious use of instruments.

If a decided tumor exist, the difficulty of diagnosis may be decreased; fluctuation and a constant relation between variations in the size of the tumor and variations in the quantity and condition of the urine indicate, when observed, the nature of the tumor. Recurring fever and chills suggest the purulent character of the contents.

In every case the possibility of the origin of the pus outside of the urinary tract should be remembered in forming a diagnosis.

When the introduction of the catheter in an old man or the subject of paraplegia, or an operation upon the bladder or urethra, is followed by the appearance of blood and pus in the urine, pain and tenderness over the kidney, chills, fever, etc., pyelo-nephritis undoubtedly exists. In the absence of such symptoms, the diagnosis must be largely based upon probabilities.

Prognosis.—The course and termination of the disease depends largely upon the cause and upon existing complications. In general the danger arises from the tendency to chronicity, whereby the probabilities of serious implication of the kidneys are increased. When caused by an infectious disease, gonorrhœa, or pregnancy, recovery may be expected; when produced by tuberculosis, it is incurable. The pyelitis following mechanical impediments to the evacuation of urine or produced by renal calculi may be improved or at least arrested by the removal of the cause; it is quite possible that recovery occasionally takes place in such cases; though the uncertainty of diagnosis vitiates the value of such opinion. When accompanied with or resulting from ammoniacal decomposition of the urine, pyelitis and the consecutive nephritis soon produce a fatal result; when due to other causes, on the other hand, it may last for many years without materially impairing the general health. Cirrhosis of one kidney may result; yet the other undergoes compensatory hypertrophy and performs per-

fectly the functions of both. In chronic cases periods of decided improvement and comparative health alternate with intervals of urinary derangement and general exhaustion. A fatal result may be caused by any of the possible complications—perforation of pus into the peritoneal or thoracic cavity, perinephritic suppuration, double hydronephrosis, uræmia, etc. As a rule pyelo-nephritis exists on one side only in chronic cases; yet bilateral inflammation from calculi is not rare. Amyloid degeneration may follow suppuration here as elsewhere in the body; in a few cases it has been noted that the kidney on the opposite side exhibits this degeneration, while that on the same side remains nearly or quite free from the amyloid change. It has repeatedly happened that after one kidney has ceased to function through disease of its pelvis, the other kidney, though free from disease, ceased to excrete, and fatal anuria followed.

Treatment.—Pyelitis, like cystitis, is often the direct result of negligence on the part of the surgeon; and prophylaxis is extremely important both in avoiding the inflammation and in preventing its aggravation. In the treatment of vesical and prostatic affections, especially in old men, the greatest care must be taken to use only clean catheters and sounds as well as to avoid the sudden evacuation of an habitually distended bladder. In the various operations for stone and for the relief of stricture in the posterior urethra, the precautions previously discussed (see Urethral Fever) may avert pyelitis and cystitis. In the treatment of gonorrhœa care should be taken to prevent irritation of the kidney, the pelvis, and the bladder by overdoses of copaiba, cubebs, turpentine, and other acrid drugs, and to avoid irritant and forcible urethral injections.

The attempt to relieve inflammation of the pelvis must be based upon a knowledge of the cause upon which it depends. If it be produced by renal calculi, the attempt to soften and remove these by free diuresis and the use of alkalies should be made. This effort is rarely successful in removing the cause, but it diminishes the irritation, washes out the inflammatory products, and thus improves the general condition. If pyelitis can be traced to the retention and decomposition of urine in the bladder, the gradual relief of this condition by careful catheterism, dilatation of strictures, division of a narrow meatus, etc., exerts a good effect upon the inflammation in the pelvis; and this can be furthered by the internal use of alkaline waters.

In all cases certain general measures are useful in the endeavor to prevent a continuance of the irritation to the mucous membrane. The patient should avoid excessive bodily exertion and should keep the recumbent posture much of the time; the diet should be so chosen as to prevent the excretion of irritating substances by the kidney; milk, eggs, and vegetables are especially needful; free diuresis should be secured by the administration of alkaline mineral waters or artificial substitutes. By securing a free excretion of alkaline or neutral urine the deposit of urates and phosphates in and upon the inflamed or ulcerated mucous membrane can be avoided. By observing the sediment it can be ascertained whether the reaction of the urine requires modification: decided acidity and the deposit of uric acid calls for the administration of the bicarbonate, the acetate or tartrate of potassium *before* meals. If, on the other hand, the urine be decidedly alkaline before entering the bladder, benzoic acid should be given as compressed tablets or pills of five grains each; three or four of these daily usually suffice to render the urine in the pelvis neutral or slightly acid.

Many attempts have been made to diminish the formation of pus by

the administration of drugs; benefit seems to have been derived in individual cases from the use of gallic acid, the acetate of lead, eucalyptol; when the disease is chronic, turpentine, copaiba, sandal-wood oil, or the fluid extract of eucalyptus may be administered in small doses only, for they may otherwise have a decidedly irritating effect upon the secreting structures of the kidney. The tincture of the chloride of iron is useful in catarrh of this as of other mucous membranes, probably for its constitutional rather than its local effect. In chronic cases iron and quinine should be administered for the maintenance of the patient's strength.

A few weeks' sojourn at a mineral spring has sometimes produced remarkably favorable results; the water selected should be of mildly alkaline reaction, containing only a small quantity of mineral ingredients.

If the attack be acute and accompanied with pain, tenderness in the loin, and vesical irritability, hot applications over the loin and groin and morphine should be employed.

Renal Calculi.

Concretions containing mineral salts are found at various points in the urinary channel, most frequently in the pelvis of the kidney. The salts of which they are composed are doubtless usually thrown out of solution in the urinary tubules themselves; indeed, concretions may be formed here. But it is as a rule only after these materials have reached the pelvis of the kidney that the anatomical conditions permit their aggregation into calculi. Sometimes these concretions involve both kidney and pelvis; in a case reported by Maring, the stone extended from the pelvis to the capsule of the kidney.

But few of the many conditions which favor the deposit of salts from the urine in the pelvis of the kidney have been definitely ascertained. It is known that such deposit occurs more frequently in childhood and in old age than in middle life, and far more frequently in males than in females. Climate, soil, and probably drinking-water influence the formation of calculi; the relative frequency of renal and vesical stones on the eastern coast of England is familiar. Even neighboring districts in the same country, where habits of life are practically identical, exhibit great differences in the frequency of stone formation—a fact which has been emphasized from personal observation by several German observers, especially Canstatt and Gerhardt.

Habits of life are certainly of importance in accounting for the formation of renal stones. A preponderance of animal diet and the excessive use of wines and beer favor the formation of uric acid concretions; sedentary habits, which so often accompany an excessively nitrogenous diet in well-to-do people, are another favoring circumstance; hence it happens that those who live in luxury are in all countries especially prone to the development of urinary stones; while it is said that those constantly engaged in active exercise, especially soldiers and sailors, enjoy almost perfect immunity from this affection (Eichhorst). The production of lactic and butyric acids in excess in the alimentary canal, either from overindulgence in saccharine and starchy foods, or from imperfect pancreatic digestion, seems to favor stone-formation.

In certain cases it would seem that there is an hereditary predisposition to the formation of renal calculi. This has been seen especially in cases of cystine stones; though these are so rare, they have been observed in dif-

ferent members of the same family. In some individuals there seems to be a general tendency to the formation of concretions on various mucous membranes—the salivary and biliary ducts as well as the urinary channel exhibiting them. Eichhorst reports a singular example in which an individual is able to produce renal concretions at will by simply drinking a small quantity of white wine, a quarter of a glass of which is sufficient to produce, after the lapse of a few hours, intense pain in the region of the kidney, followed by the expulsion of minute concretions up to the size of a pea. The gentleman, a prominent surgeon, gives the assurance that he is never troubled in this way except after drinking white wine.

Certain transient constitutional conditions doubtless serve to originate renal calculi whose existence becomes apparent only after the lapse of a long interval: thus the precipitation of urates and uric acid, usual in febrile conditions, especially in children, may result in the formation of concretions; these are doubtless usually removed by the subsequent increased flow of urine, but may remain and increase in size.

Local disturbances of nutrition in the renal pelvis favor the deposit of salts from the urine; a catarrhal or purulent pyelitis may furnish masses of pus or mucus and blood-clots upon which the urinary salts are precipitated. That this is actually the origin of calculi has been beautifully demonstrated by Ultzmann's recent microscopic researches into the composition of vesical stones. This observer made sections of calculi sufficiently thin for microscopic inspection by sawing and subsequently grinding the stones; he was thus enabled to distinguish and even to photograph with the microscope pus-corpuscles, blood-clots, and hæmatoidin crystals constituting the nuclei of the stones. Other foreign bodies in the renal pelvis also favor the precipitation of salts from the urine; thus Griesinger found that the nuclei of certain renal stones in Egyptians were the eggs of the bilharzia.

Ultzmann distinguishes between primary and secondary stone formation —a distinction of much clinical importance. The calculi of primary formation are composed of substances which may be deposited from urine whose only abnormality is a relative excess of solid ingredients; such are the concretions of uric acid and urates, oxalate of calcium, cystine and phosphate of calcium. Overindulgence in a diet which furnishes these ingredients, constitutional conditions which produce them in excess, or neglect to use the ordinary amount of drinking-water, may give the impetus to such formation. Secondary stone formation results from a previous alkaline fermentation of the urine, consequent upon diseases of the bladder or pelvis, whereby several other substances—chiefly earthy phosphates, the urate of ammonium and the triple phosphate—are produced and precipitated.

Nurslings are especially prone to the formation of renal stones; many of these are doubtless of intrauterine origin and consist of uric acid and urates. Such stones have been found in children less than a week old and even in the fœtus. In nursing children calculi composed of the urate of ammonium are not infrequent; and during the first years of life the urates are frequently precipitated within the urinary channels during slight disturbances of health, particularly during bowel complaints. Possibly these infarcts in the child serve as nuclei for calculus formation in the adult.

Yet the presence of precipitated urinary constituents in the renal pelvis is by no means sufficient to produce their aggregation into the shape of calculi; nor is such aggregation effected by the presence of foreign bodies —blood-clots, parasites, catarrhal products, etc. Many patients are constantly troubled with "gravel" and yet have no calculi; and Litten has

shown that necrotic epithelium may be coated with phosphates from the renal capsule to the pelvis without inducing stone formation. The factor necessary to secure the aggregation of the urinary salts, after precipitation, into calculi is still unknown. It is evidently something furnished by the epithelial cells of the pelvic mucous membrane or of the renal tubules; for the salts which constitute the nucleus of a stone do not exist in their ordinary crystalline forms; they are either in an amorphous condition, or are crystallized in masses (Ultzmann, Kraüche). Now it is established experimentally that the presence of a colloid material causes the precipitation of a salt, otherwise crystalline, in spheroidal masses (Rainey); and it is in just this form that the uric acid nuclei of stones, and the uric acid infarcts of infants, are found. Whatever be the nature of the colloid material entering into the formation of renal stones, its presence is certainly necessary for their production; without it the individual may for years pass quantities of precipitated uric acid, urates, and phosphates, and yet not suffer from calculi. There is certainly a predisposition, either of the individual or of certain conditions of the individual, to the production of this material; and this predisposition seems to be manifested by the production of colloid material by the epithelium of the kidney or pelvis, or both.

As a rule calculi are found and formed in one pelvis only, though their occurrence on both sides is not rare. The number of stones varies indefinitely, Gee having reported a case in which nearly one thousand were found on one side, and numerous concretions in the other pelvis. The size, too, may vary from that of sand particles to the volume of a goose-egg; in the case of Gee already mentioned one of the thousand stones weighed about thirty-five ounces. The form may be quite irregular; sometimes the concretion has taken the shape of the pelvis with a projection into the ureter, making the so-called pipe-shaped stone; in other instances the concretion fills the pelvis and exhibits projections into the calyces of the kidney.

The composition of these concretions varies; some consist throughout of a single substance, while in others concentric layers are found differing in composition and gathered around a central nucleus—an arrangement common in bladder-stones. The various substances contained in the urine may contribute to these concretions; among the most frequent are uric acid and urates, oxalate of calcium, phosphates, carbonates, and cystine; concretions composed of indigo and of xanthin have also been found. In many cases the stone is composed partly of anatomical elements derived from the pelvis, such as pus, blood, and fibrine.

In a few cases there have been found in the pelvis of the kidney concretions composed of biliary salts—in short, gall-stones. In such instances careful search has discovered a communication between the bile-ducts or the intestinal canal and the urinary passage.

The presence of stones in the pelvis of the kidney causes an inflammation of the mucous membrane, which in the most favorable cases is simply catarrhal, but is usually suppurative and may be even of so-called diphtheritic character. Ulceration is a common occurrence, and may lead to perforation of the pelvis with paranephritic inflammation and abscess. The kidney itself rarely escapes morbid changes; the most frequent and least severe is a catarrh of the medullary portion; interstitial nephritis and the formation of abscesses is a not infrequent result; indeed, the entire renal tissue is sometimes destroyed, the organ being replaced by a membranous sac containing pus, renal stones, and fragments of tissue. In rare cases a genuine chronic nephritis is the sequel.

It sometimes happens that the stone passes into and lodges in the ureter, either occluding its channel or permitting the urine to pass through a narrow groove on one side of the stone. In such cases ulceration takes place in the mucous membrane, which may result in perforation or even rupture of the ureter. Hydronephrosis also results when the escape of urine is only impeded and not arrested.

In some few cases catarrh of the bladder is observed as a result of renal calculi. This may occur not only when concretions have escaped into or formed in the bladder, but also without any apparent exciting cause other than the catarrh in the pelvis.

Symptoms.—Renal calculi are sometimes found quite unexpectedly post mortem, or they are passed with the urine without previous symptoms indicating their existence. In some cases obscure symptoms indicating rather an affection of the stomach or of the bladder than of the kidneys are produced by renal stones. In most instances, however, the presence of renal calculi is indicated by distinct symptoms which may occur at intervals for years before a positive diagnosis is possible. Foremost among these is hæmaturia, occurring periodically and accompanied with some fever and pain in the loin and groin; in children the coincident pain and fever are often lacking, and a suspicion of renal cancer is entertained. The passage of "gravel" or the precipitation of a heavy sediment while the urine is still warm, is another symptom. The bleeding is especially profuse when the stone consists of calcium oxalate; in such cases there is sometimes a decided impairment of the general health.

The presence of renal calculi may, on the other hand, be indicated early in the affection by attacks of renal colic. These are especially apt to occur after severe bodily or mental exertion, or after a blow in the region of the kidney: they have been noted also as a sequel to confinement and tight-lacing. On the other hand, they occur without apparent provocation, sometimes awakening the individual from sleep.

The most prominent symptom in renal colic is extreme pain, sometimes so acute as to cause collapse of the patient; the skin becomes cold and moist, the pulse is small and rapid, there is nausea and vomiting, perhaps even faintness, and in children convulsions. The pain is usually felt on one side only, first in the region of the kidney and then extending down the course of the ureter to the bladder, scrotum, and penis; it may also radiate down the thigh as well as across the abdomen, and even upward to the shoulder-blade. There occurs spasmodic contraction of the cremaster, and the testicle is drawn upward toward the inguinal ring. Urination is very frequent and painful, only a few drops being voided at each attempt.

This attack may cease in a few minutes or may last for several days; its duration is limited merely by the length of time during which the stone remains in the ureter. Sometimes the calculus is forced backward into the pelvis, while in other cases it is gradually pushed through the ureter and escapes into the bladder; its passage through the vesical end of the ureter is apt to be especially painful. The escape of the concretion is followed immediately by complete relief from the excruciating pain, only a sense of soreness remaining. Sometimes the pain is renewed after a short interval, indicating either the passage of another calculus or the movement of the same one farther down the ureter. The pain is usually accompanied with some fever and may be ushered in with a decided chill. The patient carefully avoids movement, which aggravates the pain, and often assumes a position on the diseased side, the lower extremities in extreme flexion.

During such an attack the urine exhibits important indications. The patient is tormented with a constant desire to evacuate the bladder, but succeeds in passing only a few drops ; indeed, this desire may exist when the bladder is really empty, as shown by the introduction of the catheter. The quantity of urine is temporarily decreased, and it may be mixed with blood in consequence of the injury to the mucous membrane of the urinary passages by the concretion. It often happens that urine which had previously contained pus becomes during renal colic quite clear in consequence of the obstruction to the ureter on the affected side, whereby the escape of pus from the inflamed pelvis is prevented.

In severe cases total anuria occurs, either because both ureters are simultaneously obstructed by calculi or because the obstruction on one side is followed by sympathetic suppression in the opposite kidney. This condition of anuria, unless soon relieved, is followed by the symptoms of uræmia ; death has occurred within twenty-four hours. Yet the anuria which follows and depends upon the lodgment of calculi in the urinary channels is certainly less dangerous than that which results from direct interference with the renal activity ; at any rate, the disastrous results occur less frequently and at a greater interval from the beginning of the anuria than in the other condition. Thus instances are recorded in which anuria from calculus impaction has existed twelve, fifteen, seventeen, twenty-five, and even twenty-eight days with ultimate recovery. On the other hand it must be admitted that cases have terminated fatally within one or two days after the establishment of the anuria ; the variation between these periods is doubtless to be explained by the condition of the kidneys at the time the obstruction occurred. In those cases in which extensive disorganization had already resulted from the presence of the calculus the fatal termination happened early.

In many cases renal calculi exist without giving rise to attacks of renal colic. The symptoms may be such as to attract attention to the kidney, consisting of hæmaturia and dull pain in the loin ; the latter increased by straightening of the spinal column, which is therefore avoided by the patient ; he bends slightly forward ; the quantity of blood may be so considerable as to attract the patient's attention, even clots of considerable size being visible, or it may be so slight as to be detected only by means of the microscope. Thus in one case which came under my observation there was nothing to indicate renal disease, and the examination of the urine was made merely for the sake of completeness ; a few blood-corpuscles constituted the only abnormality detected. During the year following, however, unmistakable signs of renal calculus—pus, pain in the loins, and pointed uric acid crystals, together with a decided increase in the amount of blood present—became apparent.

The most prominent symptoms may be those usually referred to vesical irritation or catarrh ; frequent and painful urination and a burning pain around the neck of the bladder may deceive the physician into a diagnosis of cystitis unless he makes a careful examination of the urine. Sometimes the symptoms suggest irritation of the stomach ; pain in the epigastrium, nausea and vomiting with or without diarrhœa direct attention to the digestive tract. No examination of the urine is made ; the case is regarded as one of biliary or intestinal colic.

The symptoms produced by renal calculi are frequently those of the consecutive pyelitis ; the calculous origin of the inflammation can be determined only by the exclusion of other causes and by the presence of crystals in the sediment. Yet the absence of such crystalline deposit does

not of course disprove the existence of calculi in the pelvis of the kidney. Sometimes the symptoms of renal cirrhosis are developed before evidences of renal calculi become manifest. Hydronephrosis, perinephritic abscess, discharge of pus externally or into an abdominal organ may be the first decisive indication furnished by renal stones; the cause of these complications may remain undiscovered until a post-mortem examination is made.

Women are especially liable to difficulties caused by renal calculi during pregnancy and after delivery; attacks of renal colic are not infrequently productive of abortion. Troja mentions a case in which this accident occurred fourteen times in the latter months of pregnancy, each time as the result of renal colic.

FIG. 15.—Sediment from Calculous Pyelitis; large pointed Crystals of Uric Acid, Epithelial Cells, Leucocytes and Blood-corpuscles (Ültzmann).

Diagnosis.—There are no constant and characteristic symptoms which indicate the presence of renal caluli; and these often exist for years without exciting a suspicion of their presence. The possibility of the existence of concretions in the pelvis usually becomes the subject of inquiry only after one of two consecutive conditions is discovered—pyelitis and renal colic.

Pyelitis, while frequently induced by renal stones, may also be excited by other causes; hence a careful examination of the history, mode of life, and symptoms of the patient as well as of the urine must be made in order to exclude the other possible causes of pelvic inflammation. An habitual deposit of crystalline forms, and especially the presence of pointed crystals of uric acid in considerable quantity in the sediment (Fig. 15), indicate the calculous origin of an existing pyelitis.

Attacks of renal colic are in most cases caused by renal stones; yet it is possible to make a mistaken diagnosis of renal colic which can be con-

founded with perinephritic inflammation, renal embolism, spinal caries, biliary colic, gastralgia, and even lumbago. On the other hand, a renal colic may be regarded as biliary or intestinal colic, neuralgia of the stomach, a "gastric crisis" of tabes (as happened in a personal case), etc.

In children recurring hæmaturia may be the only symptom, in which case a distinction between renal calculus and cancer is difficult. Yet if the bleeding be caused by a calculus, the general health is unimpaired, and the urine precipitates rapidly, perhaps even while still warm, a sediment containing uric acid and urates. If renal cancer exist, on the other hand, emaciation and cachexia are observed, while the urine may furnish positive information.

Occasionally genuine renal colic results from causes other than calculi, the possibility of whose existence should therefore be made the subject of inquiry. *Abortive* renal colic, consisting of one or more of the usual symptoms manifested in a slight degree, is a not infrequent occurrence which would be oftener recognized if the urine were examined.

After the existence of renal stones has been determined, it is important for both prognosis and therapy (surgical interference) to ascertain whether only one kidney is involved, and if so, which one. If pain and tenderness exist only on one side, and especially if during an attack of renal colic pus and blood disappear from the urine, it is probable that only the one side is affected. Yet these facts afford only a probability that the second kidney is healthy; for many cases, both of post-mortem examination and of surgical operation, have shown that serious disease of the second kidney, rendering it incapable of performing the functions of both, has escaped detection in this way. Positive knowledge of the condition of the second kidney—which should be considered an essential preliminary to any surgical interference—can be secured only by obtaining the urine directly from this organ. This has been done in females by inserting a catheter into the corresponding ureter; and has been attempted in males by occlusion of the opposite ureter.

After a diagnosis of renal stones has been made, it remains to determine so far as possible the chemical composition of the calculus. Its nature can be predicted with some probability from the habitual reaction of the urine and from the character of the sediment. If the urine be constantly acid, and the sediment contain copious urates and uric acid crystals, the calculus is probably composed of uric acid or oxalate of calcium, or both. If, on the other hand, the urine be alkaline from the presence of a fixed alkali, the stone is probably composed of phosphates or carbonates—a rare formation. If the urine be ammoniacal, it is probably so rendered in the bladder, and no deduction as to its reaction in the renal pelvis can be drawn. These inferences are of course mere probabilities; for the character of the urine may have radically changed since the nucleus of the renal concretion was formed; yet the composition of the outer layers at least is pretty certainly revealed by the condition of the urine.

Prognosis.—The termination of the difficulties caused by renal calculi may vary from recovery to death; and since both kidneys may be or become diseased, and serious complications are always possible, the prognosis should always be reserved. In the most favorable cases the disease is unilateral, the concretions escape into the bladder, the consecutive pyelitis subsides, and complete recovery follows. In other instances the pelvis and ureter are obliterated by inflammatory action, the kidney atrophies and ceases to secrete, and the patient experiences no further difficulty, the excretion of urine being maintained by the remaining

(hypertrophied) kidney. In other instances some one of the numerous possible complications occurs, inducing directly or indirectly a fatal result.

Individuals who have once suffered from renal calculi are apt to be tormented by their recurrence for years or even during a lifetime. In the intervals between the passage of concretions, the patient may enjoy perfect health, though a smarting pain upon urination is not infrequent even when the urine is free from crystalline sediment.

Treatment.—The most important item in treatment is prophylaxis. One attack of renal colic should be an indication for the adoption of such measures as tend to prevent the deposit of urinary ingredients within the body; indeed, before positive evidence of the existence of renal calculi is presented, various symptoms may warrant a suspicion that such a condition may be expected. A patient may complain of occasional scalding during urination, often accompanied with a burning pain at the neck of the bladder. In one case which came under my observation this symptom was first noticed under circumstances which aroused a suspicion in the patient's mind of gonorrhœa; the smarting and pain subsided, but recurred again after several days and subsequently became almost habitual. When he came into my hands, the patient had calculous pyelitis. In these cases the urine is usually highly acid and rapidly deposits a crystalline sediment; this precipitation may occur within a few minutes after evacuation or even before the urine is voided. The addition of nitric acid causes the appearance of a cloud already described as indicating an excess of urates.

It is not unusual to detect in such patients a slight albuminuria, which cannot be attributed to any lesion of the kidneys; indeed, the albumen disappears when free diuresis is secured or when the urine is rendered alkaline. These phenomena are especially prominent after free indulgence in alcoholics and hearty meals.

The presence of blood in the urine, even though in such small quantity as to be discoverable only with the microscope, is especially in children a frequent indication of renal concretions, and may be present before other symptoms have become apparent. This symptom may be transient and occur at intervals of weeks or months. If it be accompanied with decided acidity of the urine and perhaps slight tenderness upon firm pressure over the kidney, treatment adapted to the prevention of renal concretions should be instituted.

Persistent irritability of the bladder without discoverable cause is sometimes relieved by those measures which tend to prevent the precipitation of urinary ingredients within the body.

The *preventive* treatment includes a careful regulation of the diet and the ingestion of pure water in large quantity. The food prescribed must be determined somewhat by the composition of the stone. The most frequent calculi are composed of uric acid and are formed from very acid urine. The diet should therefore be such as furnishes a comparatively small quantity of uric and other acids; lean meat and alcoholics should be taken in only moderate quantity. It is a mistake to exclude these and other nitrogenous articles from the diet entirely; such a course results in an over-production of uric acid. Sugar and fat are usually regarded as productive of acids in excess; yet they can be allowed in moderate quantities. The recent careful investigations of Cantani as to the relations of food to the reaction of urine have shown that milk and cereals produce the greatest acidity, gelatinous and leguminous substances the least, while meat, sugar, and eggs are intermediate in this respect.

The regulation of the diet, while taking these demonstrated facts into consideration, should be based less upon physiological rules than upon the results obtained in each individual case; for a "rational" diet so-called will in many instances produce dyspepsia and constipation; and it is certain that indigestion—particularly a failure in pancreatic digestion—contributes largely to the excessive acidity of the urine. Hence the diet should be so regulated as to secure a perfect performance of the alimentary function, even if meat and starchy substances must be included. Excessive indulgence in food of any sort should be forbidden.

Muscular exercise is both theoretically and practically of the greatest moment in preventing lithiasis. The tendency of many patients afflicted in this way is to sedentary occupations or to absolute physical laziness. Much effort may be required to persuade the individual to take the necessary exercise; but such effort must be made. An increase in muscular activity may require a greater amount of nutritious food, which is under the circumstances not likely to do harm.

The regular use of warm baths is an important item of treatment.

The ingestion of pure water in large quantity has evident value in the attempt to prevent the formation of renal concretions of all kinds, since by increasing the water excreted by the kidneys the tendency to precipitation of the solid urinary ingredients is diminished. Since the urine is as a rule most concentrated in the intervals between the periods of digestion, water should be taken at these times especially as well as upon retiring at night. The morning urine is particularly acid and dense; hence the ingestion of water should take place freely between the evening and the morning meal; if the patient drink freely during the evening upon retiring, and at possible intervals of wakefulness during the night, this concentration of the urine, natural and usual during sleep, can be avoided.

The water chosen for the dilution of the urine should be comparatively free from mineral ingredients (especially soda and lime salts), but mildly alkaline. Good results have been obtained by the ingestion of soft water; but since this cannot always be procured and is moreover unpalatable, a more efficient compliance on the part of the patient can be secured by prescribing a mildly alkaline mineral spring water. The springs at Vichy, Carlsbad, Ems, and Baden, have especial repute for this purpose; of American springs the Buffalo Lithia, Arcadian, and Poland are valuable. They should be taken in such quantity that the specific gravity of the urine averages not more than 1.015 in summer and 1.010 in winter. If such waters be not available, diuresis and alkalinity of the urine can be secured by the administration of salts; among these the most valuable are the alkaline carbonates, acetates, and citrates; the tribasic phosphate of sodium; the benzoate and carbonate of lithia—since lithium salts have been shown by Garrod and others to possess greater solvent powers for uric acid than those of sodium and potassium. Cantani advises that in order to prevent derangements arising from a disproportion between the sodium and potassium ingredients of the blood, the salts of these bases should be mixed. The borocitrate of magnesium has been especially recommended by Madsen and may be administered as follows: Carbonate of magnesium, one drachm; citric acid, two drachms; borax, two drachms; boiling water, eight ounces. Take a tablespoonful four or five times daily. Bartholow recommends the tartraborate of potassium, a scruple of which may be given three or four times a day dissolved in plenty of water. These and the lithium salts may be substituted if the potassium salts provoke gastric or intestinal irritation.

Vegetable acids and their compounds are quite efficient in diminishing the acidity of the urine and thus preventing or arresting the formation of concretions consisting of uric acid, urates, and oxalate of calcium; for these compounds are converted into bicarbonates in the blood. On this principle the Germans highly recommend and prescribe a diet of grapes and other small fruits—the so-called "grape" or "fruit cure." This method of treatment secures the advantages of a country vacation as well as the immediate effects of the vegetable acids.

In order to secure the alkaline effect of these remedies, either vegetable acids or their compounds, upon the urine, they should be administered upon an empty stomach; for if given while the stomach contains a supply of gastric juice, decomposition occurs before they enter the blood, producing neutral salts and carbonic acid, so that the urine may be rendered acid instead of alkaline. Moreover, the acidity of the urine is normally much diminished or even neutralized during digestion; artificial aid to overcome the acidity is especially required during the intervals between the acts of digestion.

The quantity of these substances required to produce and maintain a neutral action of the urine varies in different cases, and must be determined by observation in each instance. An alkaline reaction can almost invariably be speedily secured by taking forty to fifty grains of the acetate or citrate of potassium dissolved in a glass of water every three or four hours, so that six or seven drachms of the salt and as many glasses of water are taken daily.

In administering alkalies to effect the reaction of the urine, it is desirable to avoid such an excess of alkalinity as will occasion a precipitation of the phosphates and carbonates; although these salts rarely constitute the nucleus of a calculus, yet they rapidly accumulate upon a pre-existing concretion as well as upon a catarrhal or ulcerated mucous membrane. Hence so soon as the urine is found to be turbid from phosphates at the time of evacuation, the quantity of alkali administered should be decreased or the amount of water ingested increased, to prevent possible precipitation in the renal pelvis. The occurrence of ammoniacal fermentation should be the signal for immediate cessation of the alkaline treatment, since the phosphates are rapidly deposited and aggregated into concretions from ammoniacal urine; indeed, advantage will usually be derived, under such circumstances, from the administration of benzoic acid, five grains three to five times a day, until the reaction becomes neutral or faintly acid.

If the administration of alkalies fail to relieve the symptoms produced by renal gravel and concretions, a closer inspection of the urine may show an excessive excretion of the oxalate of calcium. Concretions of this salt are far less frequent than those composed of uric acid and the urates; yet they occur in acid urine, and since their effects are less readily controlled by alkalies, their presence may be suspected if the alkaline treatment fail. In this case substances containing an excess of oxalic acid—rhubarb, spinach, black tea, cocoa, sorrel, etc.—should be excluded from the diet; Magendie thought he could trace the formation of oxalic acid concretions in two cases to the consumption of sorrel.

The medicinal treatment of oxalate calculi is as yet merely palliative; the concretions are not dissolved nor is their formation even arrested with certainty by the use of alkalies. Gallois and Fürbringer have recently demonstrated that the excretion of calcium oxalate in the urine is decidedly diminished by the simultaneous administration of the alkaline carbonates; and Esbach has shown that the presence of such carbonates

in the stomach renders oxalate of calcium insoluble. Hence under these circumstances the oxalate is not absorbed, but is expelled with the fæces. The attempts to prevent the precipitation of the oxalate in the renal pelvis by keeping it in solution through the administration of mineral acids has been a failure. It would seem that the free use of the acid phosphate of sodium might accomplish this result, since it is the presence of this salt which keeps the oxalate in solution in the urine (Neubauer). No extensive clinical trials of such treatment have yet been reported. At present, therefore, we can do nothing better medicinally than to prescribe carbonated waters and alkaline carbonates.

It is sometimes necessary to secure an acid reaction of the urine in the attempt to arrest or dissolve renal concretions. For although calculi are rarely composed of phosphates throughout, yet uric acid and calcium oxalate concretions are sometimes incrusted even in the renal pelvis with phosphates and carbonates; such a condition may be suspected if the urine be persistently alkaline from the fixed alkalies. It is to be remembered, however, that while excessive acidity of the urine results from abnormality of assimilation, excessive alkalinity arises in nearly all cases in the bladder from ammoniacal fermentation. Before attempting to remedy an alkalinity of the urine, therefore, by the administration of drugs, the physician should have positive evidence that the urine is alkaline before reaching the bladder. In some cases, it is true, ammoniacal fermentation takes place in the pelvis of the kidney as well as in the bladder; yet as a rule, it may be stated that an excess of the fixed alkalies only and not of ammonia calls for the internal administration of acids.

To neutralize alkalinity of the urine from the fixed alkalies, benzoic acid and its compounds should be administered; five to ten grains of the acid or of the benzoate of ammonium may be given as compressed tablets four or five times daily. Lactic, phosphoric, and carbonic acid, the latter in the shape of carbonated waters, have also been recommended. If these remedies fail to effect the reaction, it is probable that ammoniacal fermentation exists; this can sometimes be subdued by the free administration of salicylic acid as recommended by Fürbringer. After the coating of phosphates is dissolved, the alkaline treatment may be required. The proper time for making this change of treatment can sometimes be ascertained by repeated examinations of the urine several days after all remedies have been discontinued.

It should be stated that several physicians, among them Dr. Ralfe, have indorsed from personal observation the plan employed by Dr. Murray, namely, the use of soft or distilled water in the treatment of urinary concretions; the advantages claimed are that more perfect solution is obtained and the tendency to catarrh of the urinary passages avoided. Roberts is inclined to favor the administration of alkaline salts, while Sir Henry Thompson considers the natural waters far more efficacious than any artificial compounds. A judiciously selected spring water—free from organic material, mildly alkaline, and containing but little mineral matter —will as a rule be most palatable, convenient, and effective.

In order to secure lasting benefits from the attempt to relieve the ills produced by renal concretions, a long course of treatment is required. The regulation of the diet, the ingestion of water in excess, and the administration of the various remedies mentioned must be maintained for many months; even after the difficulty has apparently subsided, care must be taken to prevent a relapse, which may otherwise be expected.

In many cases all these measures fail to effect a cure; the patient is

partly, or for a time even completely relieved; but after each relapse his condition becomes worse, and finally suppuration in or around the kidney becomes evident. Under these circumstances, if not before, surgical interference is required; nephrectomy and nephrotomy are now recognized and successful operations. It should never be forgotten, however, that a necessary preliminary to such operation is to ascertain that the other kidney is not only present but is capable of performing its functions normally.

The treatment of renal colic consists in the administration of narcotics; morphine should be given freely by subcutaneous injections, since the stomach is too irritable to retain or absorb medicines. The inhalation of ether or chloroform may be required temporarily. Immersion in a warm bath for an hour or two often exerts a marked influence in subduing the painful contractions; hot fomentations over the groin and loin may prolong this effect materially. Various mechanical devices have been employed in special cases; thus Simpson succeeded in forcing a calculus back into the renal pelvis by standing the patient on his head and rubbing the affected side over the ureter; Simon proposed to introduce a sound into the ureter (in the female) and thus force the concretion into the pelvis. Reliquet suggests that the lower extremities be enveloped in elastic bandages, whereby an increase of blood in the kidney and of the urinary pressure may be effected.

Quite recently Edson has recommended the hydrangea arborescens and Ducasse the stigma of maize as valuable agents both for the prevention of renal calculi and for use during an attack of colic.

That the use of alkalies or of soft water is advantageous in preventing or arresting the formation of calculi in the urinary passages there can be no doubt; that they are effectual in redissolving and removing calculi already formed, is not so certain. In fact, it may be safely assumed that calculi, so long as they are retained in the pelvis of the kidney, cannot be dissolved by any medicinal remedy, since the quantity of urine with which they are brought in contact is too slight to influence them, no matter what its reaction or composition may be. It is, however, demonstrated that calculi in the bladder, surrounded by a considerable quantity of urine, can be softened and even disintegrated by artificial conditions of the urine.

It is well known that remedies of all sorts have been proposed and employed by lay as well as by professional advisers in the hope of dissolving and removing calculi in the bladder. That the symptoms caused by their presence have been ameliorated even for years is undoubted. In most cases the improvement in the symptoms was doubtless due not to any decrease in the size of the stone itself, but merely to the less irritating character of the urine; at any rate the post-mortem examination of many such patients, who had been relieved of the most troublesome symptoms by the use of alkaline remedies, has demonstrated the presence of calculi in the bladder. Sir Henry Thompson says (1882): "I cannot find that any patient, certified to have stone after sounding by a competent surgeon, has, after a course of any solvent, been again sounded or submitted to autopsy, and demonstrated to be free from stone." There are, however, several cases on record in which eminent English surgeons testified to the disappearance of all symptoms indicating stone even upon sounding, after the use of alkalies. An examination instituted under the observation of the Royal College of Physicians for the purpose of determining the merit of this plan of treatment, included among others the following four cases:

P. Appleton, sixty-seven years old, was examined at Guy's Hospital in

July, 1739, by Mr. Sharp, surgeon to the hospital, in the presence of the President and a Censor of the Royal College of Physicians. A large stone was detected. The patient took alkaline remedies for five months, during which period a large amount of "gravel" escaped with the urine. At the end of this time he was again sounded by the same surgeon in the presence of numerous medical men. No stone could be detected; the symptoms had all disappeared.

The three other cases were essentially similar, the examining surgeons being Mr. Cheselden, Mr. Sharp, and Mr. Nourse. The patients took the solvent remedies for periods of four, eight, and four months respectively. In every case considerable sand was passed during the treatment and relief from all symptoms was obtained. At the end of the respective periods specified, examination by the same surgeons failed to detect a stone. These, it must be admitted, are the rare cases of success, culled from a large number of failures.

FIG. 16.—Cylinders of Ammonium Urate; Urinary Sediment from a Nursling with Uric Acid Infarct (Ultzmann).

So far as vesical calculi are concerned, the medicinal treatment is now a matter of little consequence, since the operation of lithotrity affords a speedy and safe relief from the affection. As for calculi in the pelvis of the kidney, there is as yet no recorded case in which solution has been accomplished by medical treatment; yet there can be no doubt of the value of such agents in relieving the painful and unpleasant symptoms caused by their presence.

Calculi are sometimes found in the kidney itself, an occurrence of pathological rather than of clinical interest. These concretions are located in the tubuli and are commonly termed infarcts. Those most frequently observed are infarcts of uric acid, lime salts, bilirubin, and hæmatoidin.

Uric acid infarcts are found almost exclusively during the first two weeks after birth; they have been observed in about one-half of all the infants examined post-mortem during this period. It is a singular fact that still-born children, even those born at full term, do not exhibit such infarcts. Virchow, after a long series of observations to this effect, was inclined to regard the presence of uric acid infarcts in the newborn as a most important and positive proof that the child had breathed, and hence attached to this fact much value from a legal standpoint. In recent years it has, however, been demonstrated in repeated instances that such infarcts may be present in the kidneys of infants which have never breathed; Martin, Ebstine, Hoogeweg, and Birch-Hirschfeld have observed and reported such cases.

The urine during the first few weeks of life frequently contain a reddish powder which is deposited on the napkin; microscopic examination often shows cylinders composed of reddish-brown spheres (Fig. 16) of urate of ammonium. Such infarcts are occasionally found in the kidneys of adults, as in one instance which I examined in the Rudolfspital in Vienna. They appear to have no especial significance.

Infarcts of lime salts are found in the shape of narrow white lines proceeding from the pelvis of the kidney toward the cortical portion. Upon microscopic examination these lines are found to consist of amorphous masses of the carbonate and phosphate of calcium which lie in the straight tubules and the loops of Henle.

Bilirubin infarcts are found in the kidneys of jaundiced newborn children. The bilirubin is present in the shape of granules or of needles and rhomboidal crystals; it lies either in the lumen of the tubules, in the epithelial cells, or in the intertubular tissue. Such infarcts are often associated with those of uric acid.

Hæmatoidin infarcts are found as brown stripes in the tubules of the renal papillæ. The hæmatoidin is found seldom in crystalline form, but usually as round, reddish-brown masses. Such infarcts may be seen after any of those conditions which cause a separation of hæmoglobin from the corpuscles—extensive burns, excessive administration of chloroform or ether, transfusions, etc.

Hydronephrosis.

Dilatation of the pelvis of the kidney by the accumulation of urine is a not infrequent condition, which may be either congenital or acquired. The former class is usually the result of congenital malformations at some point in the urinary channel. Such malformation may consist in phimosis, congenital stricture of the urethra, but most frequently of an abnormal insertion of the ureter into the pelvis. For these two portions of the urinary channel are developed independently, and the insertion of the ureter is sometimes effected, not at the lowest point of the pelvis, but at some higher point, or it perforates the pelvis obliquely, making a valvular stricture. As a result, the pelvis is emptied of urine only when the patient assumes some other than the erect posture; the accumulation of urine during the waking hours results in compression of the pelvic opening of the ureter, whereby a distention of the pelvis results. Such cases afford a most favorable condition for hydronephrosis, since the obstruction to the free evacuation of urine is intermittent. For it is well established experimentally that hydronephrosis is not produced by complete and permanent obstruc-

tion, but only by incomplete or intermittent impediment; a complete and permanent obstacle to the evacuation of urine results first in slight distention of the pelvis, but subsequently in atrophy of the kidney and the arrest of the urinary secretion. The development of hydronephrosis requires the continued secretion of urine; hence it occurs only when the obstacles to such secretion are not complete nor permanent.

In some cases of congenital hydronephrosis, the affection has attained such grade before birth as to interfere seriously with delivery, and to prevent the respiratory movements of the child, and therefore cause death. In other cases there may be at birth no evidence of hydronephrosis, which nevertheless develops in the course of the early years of life.

Anatomically a distinction is made between partial and complete hydronephrosis, according as a portion or the entire pelvis is involved in the distention. The partial hydronephrosis is especially common in cases of congenital malformation in which the pelves and ureters are double; in some cases, even with single pelvis and ureter, one or more calyces become obstructed either by a valve-like fold of the mucous membrane, or by a calculus or blood-clot.

Acquired hydronephrosis can usually be traced to some obstruction in the urinary channel; such obstructions may be of very diverse nature, some of which it has been impossible to ascertain or even imagine prior to the autopsy. The most common of these are *renal calculi* in the pelvis or ureter; *stricture of the ureter* in consequence of injury from calculi; *displacement of the pelvic orifice of the ureter* by tumors of the kidney or hydatids of the pelvis; *displacement of the wandering kidney; obstruction at the vesical orifice* of the ureter by calculi, or inflammations induced thereby or by tumors; *pressure upon the ureter* by abnormally located renal vessels, by the products of inflammation around the kidney or around the womb, by cancerous degeneration of the uterus, by prolapse, versions, or tumors of the womb, by ovarian tumors, by cancer of the rectum, etc.; obstruction to the evacuation of the bladder by prostatic hypertrophy, urethral stricture, phimosis. When any of these conditions is recognized, the possibility of hydronephrosis, with consequent renal atrophy and uræmia, should be kept in mind; for even before a pronounced renal tumor is detected, uræmia may be manifested—a familiar observation in cases of uterine cancer.

As already stated, many of the conditions through which hydronephrosis is acquired cannot be recognized, and are not even suspected during the life of the patient. Such are the cases in which post mortem an abnormal attachment of the ureter to the pelvis is discovered. Lagrave relates a curious instance in which the retention of menstrual fluid in one of the cavities of a bifid uterus had caused compression of the ureter of the same side, resulting in hydronephrosis and atrophy of the kidney. In a case which I examined at the Rudolfspital in Vienna, a man seventy-four years old, there was found pronounced hydronephrosis on one side, the other kidney and ureter being normal; the cause for the retention of fluid was found in a small myoma, not so large as a bean, which was located just at the vesical orifice of the ureter in such a way as to obstruct the passage of fluid through it.

There remain also a few cases in which even post-mortem examination has failed to reveal an impediment to the escape of urine. It is highly probable that in such cases there has existed a malposition of the uterus, a perimetritic inflammation or other abnormality at the lower portion of the ureter, which had been either overlooked or whose association with the distended renal pelvis has not been recognized; or there may have existed

a valvular formation of mucous membrane, or angular curvature somewhere in the course of the ureter or pelvis, which has escaped detection or even been obliterated by the manipulation of the parts during autopsy. It is doubtless possible, moreover, that the calculi which originated a hydronephrosis may in the course of time crumble and disappear, so that no concretion is found post-mortem.

Morbid Anatomy.—This varies according to the degree of the distention. In pronounced cases the tumor consists merely of a membranous sac distended with fluid, and containing a few fragments of renal tissue; at an earlier stage the kidney is recognizable, its cortical portion compressed, its calyces enlarged. In intermediate stages the kidney is found as a cap surmounting the distended sac. If the obstruction be located low in the ureter or in the bladder or urethra, a corresponding distention of the ureter is observed, the organ sometimes attaining the calibre of the small intestine. The hydronephrosis is uni- or bi-lateral according as the obstruction involves one or both ureters. If limited to one side, the other kidney is usually hypertrophied; if bilateral or even excessive on one side only, hypertrophy of the heart is a common feature.

The inner surface of the sac is usually smooth, though often lined with urinary ingredients and sometimes ulcerated. The quantity of fluid may amount to thirty (Cielewicz) or thirty-six (Dumreicher) litres; in a case mentioned by Roberts thirty gallons of fluid were found post mortem. The nature of the liquid varies; sometimes it contains urinary salts in appreciable quantity, while at other times it approximates the character of serum. Kehrer reports a case in which the sac contained a considerable quantity of gas, supposed to be carbonic acid; the addition of acetic acid to the contents of the sac caused the further evolution of gas. This case is of practical interest, since the presence of the gas caused a tympanitic resonance upon percussion, an unusual feature in cases of hydronephrosis, which might lead to errors of diagnosis.

It is important for purposes of diagnosis to note the variations which may occur in the chemical composition of the fluid contained in a distended renal pelvis. So long as the kidney continues to perform its functions, such fluid will contain characteristic urinary ingredients, especially urea, and perhaps also uric acid, indican, creatinin; cholesterine is also a frequent ingredient. After the disorganization of the kidney has reached such a degree as to arrest the functions of the organ, the characteristic ingredients of the urine may disappear entirely from the fluid; indeed, the accumulation of catarrhal products may produce a fluid whose composition affords no clue to its origin. Schetelig reports a case from Esmarch's clinic, in which the fluid withdrawn by aspiration was of colloid nature, containing albumen, cholesterine, mucin, and paralbumen, but no urea, whereupon the diagnosis of ovarian tumor was made. The operation revealed hydronephrosis.

Symptoms.—Distention of the pelvis and ureter may cause various symptoms due to pressure upon other organs, and may, on the other hand, exist without pronounced or definite symptoms of any kind. The features of the case must naturally depend upon the size of the tumor, and especially upon the cause of the obstruction. The symptoms most frequently complained of are a sense of fulness and pain in the loins and groin, pain around the neck of the bladder, constant desire to urinate, obstinate constipation, shortness of breath from interference with the action of the diaphragm. Sometimes the patient's attention is first directed to the region of the kidney by sudden pain following violent motion; such pain may be

followed by chill, fever, and vomiting. These symptoms are most apt to occur in cases of wandering kidney, in which obstruction is suddenly induced by a change in the position of the organ, in cases of sudden dislodgment of calculus, etc.

Intermittent changes in the quantity and character of the urine constitute an occasional symptom of this condition; a complete closure of the partially obstructed ureter is followed by the expulsion of clear urine in diminished or normal quantity according to the degree of compensatory hypertrophy of the other kidney and of the left ventricle; a partial removal of the impediment (such as a change in position of an obstructing calculus) is followed by a sudden increase in the quantity of urine expelled, which is often somewhat turbid. During the temporary obstruction a tumor may become apparent in the region of the kidney, or a previous swelling is decidedly increased; with the increase in the amount of urine expelled, this swelling subsides.

The urine itself may afford no positive symptoms; evidences of pyelitis —mucus, pus, and blood—are frequently present, but do not necessarily indicate hydronephrosis. Polyuria, caused by hypertrophy of the left heart, is a frequent symptom. This cardiac hypertrophy deserves far more attention as a symptom of hydronephrosis than it commonly receives. It results from the atrophy of the renal structures caused by compression by the tumor; and this atrophy is often aggravated by an actual and independent renal inflammation.

After the distention has attained a certain size, a tumor is perceived through the abdominal wall; it may even be possible to distinguish the distended ureter. The tumor is fixed (except in the case of a wandering kidney) and lies behind the colon. Fluctuation may be detected. This tumor may maintain for years the same dimensions, and then suddenly increase in size without apparent ground. Alternating enlargement and decrease of the tumor, the latter amounting even to total disappearance, has been observed in consequence of variations in the amount of obstruction; these phenomena were especially pronounced in a case of wandering kidney with hydronephrosis, evidently in consequence of variations in the amount of curvature of the mobile ureter.

Various complications may conceal the primary affection; such are the results of adhesion of the sac to adjacent organs. The formation of these bands is accompanied with sharp pains and tenderness upon pressure; and the attachment of the sac may displace or compress neighboring organs, causing disturbances whose origin is obscure. Compression of the colon occasions obstinate constipation and an accumulation of fæces; of the stomach, dyspepsia, nausea, and vomiting; of the lungs, dyspnœa; of the heart, palpitation, etc. Hydronephrosis on the left side presses the spleen and lungs upward, the heart toward the median line, the stomach and transverse colon toward the right; if on the right side the tumor displaces the liver upward toward the left and front, the transverse colon downward, and causes the stomach to assume a nearly vertical position. The adjacent colon—ascending or descending according to the side affected—is pushed toward the median line, but still lies in front of the tumor.

Suppuration may take place around the sac, marked by chills, fever, irregular sweats, diarrhœa, emaciation, etc.; occasionally perforation occurs into the peritoneum, the intestine or other organ. In one case Dittel observed spontaneous rupture of the distended pelvis and of the corresponding renal artery.

Complete anuria may occur suddenly; in fact, it has been observed as the first symptom which aroused suspicion of hydronephrosis. For the production of anuria it is not necessary that both ureters should be obstructed by calculi or other impediment; for a sympathetic suppression of the urinary secretion in one kidney can occur when the ureter of the other side is suddenly obstructed. This is a rare event, since the arrest of secretion in one kidney usually excites the other to increased activity and hypertrophy.

The course and termination of hydronephrosis vary in different cases. The most favorable results occur in those cases produced by renal calculi; in these the concretion is sometimes softened and escapes, an event followed by an arrest of the renal disorder; or the obstruction may be complete, leading to atrophy of the kidney, arrest of secretion, and ultimate shrivelling of the sac. If the obstruction to the escape of urine consist in a malposition of the uterus or a pelvic inflammation, a removal of the cause and hence of the effect is sometimes achieved. In most cases, however, the obstruction cannot be removed, perhaps not even detected; and a fatal result finally ensues either from uræmia or other complication.

Uræmia, acute or chronic, from atrophy of the renal substances or from serious obstruction in the urinary channel, is a frequent occurrence, and one which may arise without previous suspicion of the existence of hydronephrosis. The origin of such uræmia, indeed the nature of the symptoms produced by it, often pass unrecognized in those cases of hydronephrosis in which the obstruction is located in the lower part of the urinary channel; I have examined post mortem four cases of fatal uræmia from cancer of the uterus, where but little of the renal tissue remained, although no decided tumor was perceptible through the abdominal wall; in two of these cases no suspicion of hydronephrosis was entertained during life.

Diagnosis.—A positive recognition of hydronephrosis is possible only when a fluctuating tumor is apparent. Without this symptom a conjecture can be based upon a knowledge of the existence of an impediment in the urinary channel, calculous pyelitis, sharp pains over the kidney, sudden variations in the quantity of urine. Uræmic symptoms in cases of uterine cancer, or other known obstruction to the exit of urine, should also direct attention to this possibility.

After a fluctuating tumor is developed, there still remains much difficulty in distinguishing hydronephrosis from ovarian cyst and hydatids of the kidney. The history and mode of development may furnish valuable information, especially in the distinction between hydronephrosis and ovarian tumor. The former is first noticed at the upper part of the abdomen, just under or below the last rib; there is often a history of urinary disorders—hæmaturia, the passage of gravel, renal colic, etc.; an ovarian tumor usually begins in the iliac or inguinal region; it is commonly associated with some disorder of menstruation; the uterus is displaced and usually immovable. There is nothing about a renal tumor which need affect the uterus; yet this organ may exhibit a displacement and fixation from independent causes coexisting with the hydronephrosis; indeed, such malposition may be the cause of the pelvic distention.

The examination of the tumor itself may enable one to distinguish between the two affections; tumors of the kidney are usually located behind, those of the ovary in front of the large intestine; the former are as a rule fixed, the latter movable, though exceptions occur to all of these general rules. Exploration through the rectum as practised by Simon has occa-

sionally furnished valuable information as to the origin and location of a tumor. Inflation of the intestine (Wells) or its distention with water (Simon) has been recommended as an aid in outlining the tumor by palpation.

Examination of the contents obtained by aspiration may furnish positive information; yet such puncture is not devoid of danger, since even when most carefully performed, it has been followed by local suppuration and even peritonitis—probably because the thin fluid so readily escapes through even a small opening. The presence of urea in considerable quantity (.1 to .5 per cent.) and of uric acid may be considered proof of the renal origin of the tumor, especially if albumen be absent or present in very small quantity (not to exceed .1 per cent.); yet the absence of urinary ingredients, and even the presence of paralbumen and colloid matters does not necessarily prove the ovarian origin of the swelling. The granular cell which Drysdale pronounced characteristic of ovarian cysts is found also in certain renal tumors. An abundance of cylindrical cells indicates an ovarian tumor, of squamous cells a hydronephrosis; yet such cells are not always found in considerable quantity, and even when present do not justify a positive diagnosis. In fact, in spite of all diagnostic precautions, the most skilful surgeons, including Billroth and Esmarch, have mistaken hydronephrosis for ovarian tumor.

There is another measure which might furnish means for a positive distinction between hydronephrosis and other fluctuating tumors in the renal region—catheterization of the ureter. This is as yet practically impossible in the male, though fortunately the difficulty of recognizing hydronephrosis is less in males than in females, in whom confusion with ovarian tumors may occur. The one objection to the employment of this manipulation in differential diagnosis is the difficulty of its execution; Simon's method is unsatisfactory, and Grünfeld's requires a practised hand; but Pawlik's can be readily performed and should be employed.

A distinction of hydronephrosis from renal hydatids has sometimes been made by a previous history of echinococci, by the detection of a distinct hydatid thrill, etc. The escape of hooklets with the urine is, however, the only absolute distinctive feature of renal hydatids; the thrill has been elicited in cases of simple hydronephrosis. The fluid of a hydatid cyst ordinarily contains an excess of common salt, more than is found in any other tumor except occasional cases of hydronephrosis.

Tumors of the kidney can usually be distinguished from those of the liver by palpation and by Rosenbach's method—the inflation of the stomach with carbonic acid gas, whereby the liver is pressed forward against the abdominal wall, while the kidney is covered by the distended stomach.

Treatment.—This must vary with the cause; if renal calculi be discovered or suspected, the treatment should be an attempt to remove these; if no cause be apparent, a careful examination of the lower portion of the urinary tract, and in females, of the uterus and perimetritic tissue, should be made; urethral stricture, uterine displacement, etc., should be corrected. Gentle pressure upon the tumor and along the ureter has been tried; but since rupture of the sac is a possibility, such manipulation must be performed with extreme caution if at all. Roberts refers to a case in which the tumor was "diligently manipulated in every direction with the aid of a lubricating ointment on alternate mornings. After the third manipulation the patient suddenly passed a large quantity of urine, and the tumor forthwith subsided, and did not again return so long as the patient continued under observation."

Repeated puncture of the sac has been practised, sometimes with comparative success and in other cases with fatal result. In a case related by Roberts, eight quarts of fluid were withdrawn in January, 1852, and three and a half quarts in December of the same year; on each occasion it was noticed that after some of the fluid was removed, the remainder flowed along the ureter. The patient remained well for eight years, when seven quarts were again removed; some months later rupture of the sac and fatal peritonitis ensued. The cause of the hydronephrosis was found in the arrangement of the ureter, which entered the pelvis obliquely through its wall. This anatomical peculiarity (which has been repeatedly observed) explained the fact that when the pressure had been relieved by the removal of some of the liquid, the remaining contents of the sac escaped along the natural channel.

Various surgical measures have at different times been employed for the relief of this condition, with varying degrees of success. Puncture and subsequent injection of iodine have caused the obliteration of the sac, but are liable to induce dangerous suppuration. Free incision has been made into the sac, followed by drainage and injections of iodine; the incision has been made usually in the lumbar region, occasionally through the abdominal wall; König made the latter operation with double division of the peritoneum: a year later a minute fistula was the only remnant of the difficulty. There usually remains a permanent fistula through which urine escapes, at least until advanced atrophy of the kidney occurs.

Until greater experience with these operations has been recorded, no rules can be formulated; each case calls for thorough investigation and the exercise of the greatest discretion and care on the part of the surgeon.

Syphilis of the Kidney.

The syphilitic taint frequently manifests itself in an affection of the kidney. Upon post-mortem examination there are found gummata in different stages, sometimes as miliary nodules, which may readily be mistaken for tubercles, or as large as peas, enclosed in a connective-tissue capsule. In this as in other organs gummata are prone to cheesy degeneration; the cheesy masses are ultimately replaced by a cicatricial tissue whereby the kidney is deformed and often divided into lobes such as are seen in the fœtal kidney. This lobulation of syphilitic origin can be distinguished from that which occurs as a persistence of fœtal formation by the following features: in the former the lobules are irregular, the lines of demarcation composed of cicatricial tissue, to which the (usually thickened) capsule is adherent; in the fœtal kidney the capsule extends over but does not dip into the sulci between the lobules.

Gummata of the kidney are multiple and are not recognizable during life.

Syphilis is responsible for cases of Bright's disease, both the chronic parenchymatous and interstitial; and there is reason for believing that an acute nephritis frequently results from the same cause. Syphilitic nephritis presents no characteristics whereby it can be distinguished from inflammation due to other causes; the diagnosis must rest upon the existence of the specific infection in the individual and upon the effects of specific remedies. The occurrence of nephritis in a subject of syphilis should be considered an indication for the employment of the iodide of potassium and of mercurials in small doses; it renders more favorable the prognosis of the disease.

Renal inflammation may originate in congenital as well as in acquired syphilis; in the former case cysts of the organ are usually found.

Tuberculosis of the Kidney.

Tuberculosis occurs in the kidney in connection either with general tuberculosis or with the same affection in other of the genito-urinary organs; in the former case the tubercles are disseminated, in the latter localized.

As an accompaniment of general miliary tuberculosis and of pulmonary consumption, miliary tubercles are formed in the kidney. They are located chiefly in the cortex, and are often arranged in rows parallel with the course of the straight arteries. The gray color renders these tubercles easily discoverable when they are located directly under the capsule of the organ; upon section they are less readily distinguished in the substance of the kidney, especially if the organ be anæmic. Aggregations of miliary tubercles into masses as large as peas are found in the kidney as in other organs; these may undergo cheesy degeneration.

Such tuberculosis of the kidney is most frequent in childhood. Clinically it is a matter of little moment, since it can be but rarely recognized before death, and then only by the association of an obscure renal affection with pronounced tuberculosis of other organs. According to Rosenstein, anuria is a frequent symptom of renal tuberculosis in children.

Primary renal tuberculosis is rarely limited to the kidney, but usually involves other portions of the urinary and parts of the genital tract; indeed, it seems probable that the tuberculosis has often begun in the bladder, the epididymis, or the prostate, and has subsequently extended to the kidney.

In many cases tuberculosis is found in other as well as the genito-urinary organs; yet instances are not rare in which the disease is confined to the urinary tract, having apparently originated in a tubercular, scrofulous, or simply purulent affection at some point in this tract or in the vertebral column.

Morbid Anatomy.—Primary tuberculosis usually affects one kidney, more frequently the right (Meckel); the other may be perfectly healthy or the seat of chronic inflammation; in one case the second kidney was transformed into a medullary cancer (Rosenstein).

In the kidney itself there is observed a diffuse inflammation with the aggregation of tubercles into masses of varying size; a large part or even the entire organ may be transformed into a cheesy mass. At a later stage this cheesy material breaks down and is expelled with the urine, leaving cavities in various portions of the organ; sometimes the entire kidney is transformed into a sac containing lumps of cheesy material. The process usually begins in and progresses from the papillæ. The increase in size of the organ may be extreme; Klebs describes a case in which the right kidney was eleven inches long and weighed seventy ounces (instead of five).

The pelvis of the kidney is dilated and filled with cheesy masses which occlude the ureters and thus favor the development of hydronephrosis. Ulceration of the mucous membrane of the pelvis and the formation of fistulous openings into the surrounding tissue is a frequent occurrence, sometimes producing perinephritis, abscess, or peritonitis.

Similar enlargement and cheesy degeneration are found in the ureters,

the prostate, the seminal vesicles, the vasa deferentia, and the epididymis; the mucous membrane of the bladder is frequently ulcerated. The disease extends to the genital organs less frequently in the female than in the male.

Sometimes the primary lesion is caries (tuberculous) of the vertebræ; or tuberculosis of the intestinal canal, of the peritoneum, and of the ovaries is also present. In many instances miliary tuberculosis of various organs and pulmonary consumption are found.

The etiology of primary genito-urinary tuberculosis is by no means clear. Hereditary influence seems to be a factor of importance in tuberculous disease of these as of other organs. Previous inflammation of the genital organs seems to be a predisposing moment; the disease is found most frequently in males and during the period of sexual activity. Nearly all cases observed have been between the ages of fifteen and forty-five years, though in rare instances it has been seen as early as in the third and as late as the seventieth year. The patient's history usually includes a previous chronic gonorrhœa, chronic cystitis, or epididymitis. In many cases the advanced stage of the process in the prostate, seminal vesicle, or epididymis indicates that the tuberculosis began in these parts and subsequently appeared in the kidney. Intervening portions of the urinary tract—the ureter or the bladder, for example—may be entirely free from the affection which has appeared both below and above. Tuberculosis of the kidney and of the genital organs is observed far less frequently in females than in males.

Symptoms.—So long as the kidney contains only miliary and submiliary tubercles the recognition of the affection is impossible, though conjecture to that effect may be based upon the existence of tuberculosis in other organs, especially in the genito-urinary tract. At a later period, when pus and cheesy masses are formed and expelled with the urine, tuberculosis of either the kidney or the bladder probably exists. The differential diagnosis between the two is often difficult; for tuberculosis of the kidney and its pelvis often produces the symptoms of cystitis—frequent and painful urination, ammoniacal and purulent urine; the existence of these symptoms does not therefore warrant a diagnosis of cystitis. In other cases the symptoms point to the kidney as the seat of disease; the patient experiences extreme pain in the renal region, often paroxysmal; the pain may extend along the ureter and to the neck of the bladder, or may radiate toward the navel and down the thigh; sometimes there is numbness of the lower extremity. On the other hand, tuberculosis of the kidney may attain an advanced stage without causing any pain in the region of the organ. After a time a tumor may become perceptible, due in part to increase in the size of the kidney itself, and in part to distention of the pelvis by the urine in consequence of obstruction of the ureters by cheesy masses; the expulsion of such masses with the urine may produce renal colic, and be followed by a reduction in the size of the renal tumor. In a few cases an intermittent tumor has been observed; its appearance is accompanied with severe pain, while the urine becomes unusually clear and scanty; after a time the pain suddenly ceases, the tumor disappears, and the urine becomes more profuse and turbid as before. Such phenomena are caused by the repeated plugging of the ureter by cheesy masses and fragments of tissue, with consequent hydronephrosis. Eichhorst observed for two years continuously a patient who exhibited such phenomena every two or three weeks.

The urine is usually acid and of normal quantity and specific gravity;

even after a considerable portion of one kidney has been obliterated by the tuberculous process, the quantity of the urine may remain normal from the vicarious increase of activity of the other kidney. If both organs are affected, the quantity of urine is gradually diminished, and uræmia may ultimately occur.

The urine contains pus, and in many cases minute cheesy masses as large as a pin's head can be discovered in the sediment. These masses afford strong suspicion of tuberculosis in the kidney and its pelvis, though they can proceed from the same affection in the prostate or neck of the bladder.

Since Koch's discovery of the bacillus of tuberculosis and its constant association with tuberculous lesions in all organs, this organism has been sought in the urinary sediment from cases of suspected renal tuberculosis. In a few cases the bacillus has been detected (Rosenstein, Cornil, Lichtheim, Babes), and section has subsequently revealed the accuracy of the diagnosis. While the presence of this bacterium is certainly positive evidence of the existence of tuberculous inflammation at some point of the urinary tract, the failure to discover it does not prove the absence of such changes.

If the bladder is also involved, dysuria becomes a prominent symptom. The urine may remain acid for a considerable time, but finally becomes ammoniacal. Occasionally the urethra is obstructed by a fragment of tissue, causing retention. It is to be remembered that these symptoms of vesical irritation may be present without participation of the bladder in the tuberculous process. In many instances kidney and bladder both exhibit tuberculous lesions.

Diagnosis.—The diagnosis of tubercular disease in the genito-urinary tract is based upon the presence of pus and cheesy particles in the sediment; the detection of tubercle bacilli in the same; the symptoms of derangement of the kidney or bladder; nodular thickening in the epididymis, prostate, or seminal vesicle; the existence of tuberculosis in other organs. In the absence of perceptible changes in those parts of the genito-urinary tract accessible to the finger, and of the tubercle bacilli, tuberculosis of these organs can be at most suspected.

In certain cases intermittent hæmaturia associated with occasional dull pain in the loins have been the only symptoms observed; if accompanied by hectic, night-sweats, emaciation, etc., a suspicion of renal tuberculosis should be entertained. König's observations show that tuberculosis of the urinary tract is sometimes found in individuals with chronic (tuberculous) inflammation of various joints. The existence of such "idiopathic" synovitis should therefore be taken into consideration in determining the nature of an obscure urinary complaint in such patients. Tuberculosis of the urinary tract, like the same affection of the lungs, is less troublesome in warm than in cold weather, and in a dry and uniform than in a moist and changeable climate—a fact of diagnostic importance.

It is often difficult or impossible to determine the locality and limitation of the tuberculous process in the urinary tract; the symptoms and urinary appearances may be extremely similar, whether the inflammation be localized in the bladder or the kidneys. The kidney is, however, far more frequently affected than the bladder; hence the recognition of tuberculosis in the urinary tract affords a strong presumption that the kidney is affected, even though there be no positive symptoms referable to this organ.

Tuberculosis of the kidney must be carefully distinguished in childhood from the malignant growths and from lithiasis; the latter condition often

indeed coexists during early life. In adults, in whom renal cancer is rare, calculi of the kidney or of the bladder may be mistaken for the tuberculous process.

Prognosis.—The disease is incurable and always tends to a fatal termination, which is usually hastened by tuberculosis of other organs. This termination may, however, be deferred many years; cases are known in which the urinary tract only was the seat of tuberculous disease, for ten, fifteen, and even seventeen years. So long as the disease is confined to the urinary and genital organs, its progress is usually slow; yet a fatal result may occur suddenly from complications such as peritonitis, uræmia, or secondary general miliary tuberculosis. The average duration is considered about one year.

Treatment.—Remedies are powerless to affect the course of the disease, and are useful only in mitigating the symptoms. The treatment required for supporting the patient's strength is essentially that employed in cases of pulmonary tuberculosis—tonics, quinine, iron, and cod-liver oil. Tuberculosis of the urinary tract, like the same affection of the lungs, is as a rule much less troublesome in warm than in cold weather, and is equally benefited by residence in a warm, dry, and uniform climate. This influence of atmospheric surroundings upon the course of the disease constitutes an important item in diagnosis (in the early stages) and in prognosis; for the improvement witnessed upon the return of warm weather after the cold of winter may deceive the patient and even the physician into the belief that recovery has occurred.

In subjects who exhibit a scrofulous or tuberculous tendency, prophylaxis is extremely important; chronic suppuration in the urinary tract —gleet, cystitis, etc.—may become a focus of tuberculous inflammation, and should hence be arrested at once.

Cancer of the Kidney.

Cancer of the kidney, like that of other organs, may be primary or secondary. Primary cancer occurs almost exclusively in early childhood and in advanced years; several cases are recorded in which it existed at birth (Weigert, Kühn), and some others where it was discovered during the first three months of life.

This frequency of cancer of the kidney in early life is quite remarkable, since the disease rarely occurs in other organs during childhood. The fact accords with Cohnheim's hypothesis as to the origin of cancer—its rise from the persistence of fœtal aberrations; for the kidneys, as is well known, begin their function early in fœtal life and are especially prone to exhibit a persistence of embryonic peculiarities. Among twenty-nine cases of cancer in various organs during childhood reported by Hirschsprung, fifty-two per cent. were cancer of the kidney; of these thirty per cent. were developed during the first five years of life, and the remainder previous to the tenth year. In another respect, too, cancer of the kidney differs from cancer in general, namely, that it is found with far greater frequency in males than in females. This difference is less apparent in childhood than in adult life.

Secondary cancer of the kidney may follow carcinoma of various organs, but is an especially frequent sequel to cancer of the testis.

Certain other tumors of the kidney are usually indistinguishable from cancer, and if recognized at all during life are designated by this name.

Foremost among these is sarcoma, which occurs usually as a metastatic growth and therefore in both kidneys. Primary sarcoma of the kidney is extremely rare; Koch has recently reported one in the right kidney of a woman fifty-five years of age. Myosarcoma has also been observed as a primary affection. Myosarcoma containing striated muscle fibres has been described by Cohnheim, Marchand, and others as occurring in children during the first five years of life. Adenoma of the kidney is according to Sturm not a rare affection, though it is usually regarded as cancer. Fibroma has been repeatedly observed as small circumscribed nodules in the medullary portion; Wilks described a case in which the entire right kidney was transformed into a fibrous tumor, the autopsy occurring ten years after the patient, a woman fifty-three years old, had experienced pain over the kidney and had had hæmaturia. Lymphangioma, cavernoma, myxoma, lipoma, and gumma have all been observed post-mortem in the kidney, but are rarely detected during life.

The kidney furnishes less than one per cent. of all cancers. Renal cancer is often associated, especially in children, with calculi in the pelvis; probably either favors the development of the other; morbid blood-clots and fragments of tissue serve as nuclei for concretions, while calculi may by their irritation further the development of cancer.

Morbid Anatomy.—These vary according as the cancer is primary or secondary: primary cancer is found as a rule in one kidney only, most frequently the right, and occurs as a diffuse infiltration; secondary cancer, on the other hand, is usually found in both kidneys and as circumscribed nodules.

In most cases of primary cancer especially the kidney is much enlarged, often attaining four or five times its normal size and constituting a tumor which may occupy a large portion of the peritoneal space. In two cases, one reported by Roberts, the other by Van Den Byl, the growth weighed over thirty pounds.

The surface is usually uneven and nodular. Upon section there is often found a considerable remnant of normal renal tissue, sharply defined from the cancerous mass which constitutes the remainder of the organ. The cortex is chiefly, sometimes solely, affected. The color and consistence of the tumor vary with its structure, being sometimes soft and encephaloid, and at other times of unusual hardness. The tumor is extremely vascular and often exhibits extravasations of blood in its substance and in the perinephritic tissue; cavities containing a dark brown fluid are discovered in the interior of the mass.

In consequence of the size of the tumor, displacements of other abdominal organs are frequently observed; spleen, liver, and stomach suffer especially in this way; sometimes pressure of the mass upon the duodenum has occasioned dilatation of the stomach.

The cancer is often found to have extended into adjacent structures, especially the pelvis and ureter and the renal vein. It may happen that particles of the tumor have obstructed the ureter and thus led to hydronephrosis. Extension of the growth into the renal vein and even the ascending vena cava has been observed; implication of the iliac vein by continuity has also been noted. The lymph-glands in the vicinity of the kidney are usually enlarged and cancerous. Their enlargement together with that of the diseased organ itself may result in compression of vessels and nerves with consequent impairment of function of the lower extremities—neuralgia, paralysis, atrophy, œdema, etc.

The other kidney is often of normal appearance except for a slight

enlargement; yet it frequently exhibits some abnormality other than cancer. Thus chronic nephritis, amyloid degeneration, extravasations of blood in the renal substance and in the pelvis have been noted; in one case reported by Dadt and Rosenstein there was observed medullary cancer of one kidney and tuberculosis of the other.

Metastases from primary cancer of the kidney are not frequent and are found chiefly in the lungs. Cancer of the testis is often found, though the urinary channels escape entirely.

Symptoms.—Secondary cancer of the kidney usually remains undiscovered during life. Many cases of primary cancer also exhibit no symptoms upon which a positive diagnosis can be based.

The cardinal symptoms in a typical case are *tumor, cachexia, pain, hæmaturia.* One or more of these is often absent, the swelling and cachexia being the most constant symptoms.

In children the tumor often attains an enormous size, the swollen abdomen traversed by large cutaneous veins contrasting sharply with the emaciated and bloodless appearance of the remainder of the body. In adults there is frequently no trace of a tumor.

Pressure and displacement of other organs by the renal enlargement occasion symptoms which may mislead the physician by directing his attention to supposed derangements of the alimentary canal. Heart and lungs, stomach, liver, spleen, and intestines may be forced into abnormal positions, as already described in discussing hydronephrosis. Motor and sensory disturbances of the lower extremity may be prominent and for a long time almost the sole symptoms; they are caused either by simple compression of nerves or by actual invasion of the vertebral column and the spinal cord by the malignant growth. The cancer may extend into these structures without producing an enlargement distinctly perceptible through the abdominal walls. Among the symptoms thus produced are neuralgias of the lower intercostal nerves, of the ilio-lumbar region, of the hip-joint and thigh—subjecting the patient to futile treatment for rheumatism, sciatica, and neuralgia; pain, itching, numbness and paresis of the lower extremity are also experienced. Such symptoms should direct attention to the kidney as the possible seat of malignant disease, especially if the patient be less than five or more than sixty years of age.

Upon careful examination it may be possible to detect an enlargement of the kidney, usually sensitive to pressure. It lies as a rule behind the colon, which is often distended with gas and displaced somewhat toward the median line. Light percussion may give only the tympanitic resonance of the intestine, while deep percussion reveals the dulness of the underlying tumor. This latter is generally hard, uneven, perhaps presenting decided nodules upon its surface, and is thus distinguished from hydronephrosis; yet fluctuation can often be felt in spots in consequence of the collection of liquid in the cavities already mentioned; indeed, actual hydronephrosis is a not infrequent complication whereby the physical characters of the neoplasm are obscured. A malignant tumor is generally sensitive to pressure; it may exhibit slight pulsation suggesting an aneurism, and vascular murmurs are sometimes heard.

Cachexia is a prominent and, in children, an early symptom, aggravated by pain and sleeplessness, gastric and intestinal derangements, and loss of blood.

The pain is by no means constant, nor when present continuous. In some few cases it is never referred to the region of the kidney, but is felt in the groin and the thigh; in other instances attacks of renal colic occur,

caused by obstruction to the escape of urine by blood-clots and particles of tissue.

Hæmaturia is an important and frequent, though by no means constant, symptom of renal cancer. It may occur with or without pain, and is sometimes noticed for the first time after a blow or other injury to the back. The bleeding is not constant; it may cease for days or weeks and again appear without provocation or without pain. Such hæmaturia indicates as a rule a morbid growth in either the kidney or the bladder. The quantity of the blood may be so slight as to be discoverable only with the microscope, or so profuse as to occasion much alarm. Blood-clots are sometimes passed; these may be shaped like quills and thus indicate that the hemorrhage has occurred above the ureters. Rapid enlargement of the tumor may be observed in consequence of occlusion of the ureters by these clots; such obstruction is accompanied by colicky pains and oliguria. In rare instances fatal hemorrhage from the renal growth has occurred.

In a few cases there have been found, entangled in the blood-clots in the urine, particles of tissue which reveal upon microscopic examination the cancerous nature of the growth. Extreme caution must be exercised in asserting the cancerous origin of individual atypical cells which may be found in the urine; for the mucous membrane of the urinary passages may in normal or catarrhal conditions furnish cells of great diversity in size and outline. Aside from the blood and possible fragments of tissue, the urine may exhibit no abnormality; albuminuria is occasionally observed, but usually when the other kidney is the seat of inflammation.

The course of the disease varies extremely in different individuals. It seldom lasts more than two years after the discovery of positive symptoms; in children a fatal result may ensue within a few weeks, while in adults the disease is said to have continued for ten, fifteen, and even eighteen years. Periods of comparative comfort and decided improvement in health may alternate with the usual symptoms.

Death occurs from exhaustion, or from some complication, such as perforation and peritonitis, fatal hemorrhage, thrombosis of the renal vein and subsequent embolism in the lungs or brain, or perforation externally, with subsequent septic infection.

Diagnosis.—Two chief symptoms of renal cancer are *tumor* and *hæmaturia*. The former is rarely absent in children, but is by no means a constant symptom in adults; hæmaturia, on the other hand, is frequently absent, having been observed in only about one-half of the cases reported. Moreover, it sometimes appears only near the termination of the case, when other symptoms have established the diagnosis; and since hæmaturia is a symptom of many other affections of the urinary tract, it does not constitute strong evidence of the existence of renal cancer except in the absence of other possible sources of hemorrhage. When it occurs without pain and unaccompanied by other foreign ingredients in the urine, and especially when it is intermittent, hæmaturia warrants a presumption of renal or vesical cancer. The insufficiency of these two symptoms for the general recognition of cancer of the kidney is illustrated in the following table of 115 cases collected by Rohrer:

Tumor was observed in.....	47 cases	(41 per cent.).
Hæmaturia, in.....	37 cases	(32 per cent.).
Tumor and hæmaturia, in.....	25 cases	(22 per cent.).
Neither tumor nor hæmaturia, in...	36 cases	(31 per cent.).

In nearly one-third of these cases, therefore, both of the prominent symptoms of renal cancer were absent, while in less than one-fourth were the two symptoms associated.

Bartels collected from the literature the records of 52 cases; in 49 of these there was observed an appreciable tumor, while hæmaturia was noted only 24 times in 50 cases. Of 64 cases noted by Roberts, an abdominal tumor was detected in 61. It is noteworthy that a failure to detect a tumor in cases of renal cancer has happened only in adults; the absence of appreciable tumor in a child is almost positive proof of the non-malignant nature of the difficulty.

The recognition of renal cancer is practically impossible unless a tumor can be detected; yet the existence of a tumor, even with occasional hæmaturia, does not necessarily exclude other affections, since various other enlargements—of the kidney as well as of other abdominal organs—may occupy the renal region. The distinction among these is often extremely difficult and sometimes impossible.

The differential diagnosis is less perplexing in children than in adults for two reasons: the symptoms of renal cancer, especially the tumor, are more pronounced, and other enlargements in the region of the kidney are less frequent. In the child a large renal tumor is usually one of three things: congenital cystic degeneration, hydronephrosis, or primary cancer. Cystic degeneration is congenital, it has existed from birth and does not cause the constitutional symptoms produced by cancer. Hydronephrosis is also often congenital and in children frequently exhibits the other prominent symptom of renal cancer, namely hæmaturia (from renal concretions). The consistence and form of the tumor, but especially the history of the case, usually render the diagnosis between the two easy.

In adults the recognition of renal cancer is less certain. Even when an appreciable tumor exists it may be mistaken for an enlargement of the liver, spleen, ovary, pancreas, retroperitoneal glands, or for a perinephritic or psoas abscess, or fecal impaction.

Tumors of the liver are usually associated with disorders referable to that organ; they exhibit the movements during respiration performed by the liver. Unless a renal tumor be very large, the fingers can usually be insinuated between its upper border and the edge of the liver. The colon generally lies in front of the kidney, but not of the liver.

Greater difficulty is experienced in deciding whether a tumor of the left side proceeds from the kidney or the spleen. The same general principles involved in the distinction between renal and hepatic tumors may render the distinction possible. Sometimes the lower edge of an enlarged spleen can be distinctly grasped and recognized; moreover, a previous history of leucocythæmia directs suspicion to the spleen. Nevertheless mistakes of diagnosis seem inevitable; for profuse hæmaturia may occur in leucæmic patients without malignant disease of the kidney. Thus Roberts relates a case of "enormous enlargement of the spleen (leucocythæmic) with profuse hæmaturia for several days. After death, some months subsequently, the kidneys and bladder were found perfectly healthy." It is generally stated that renal tumors are distinguished from those of the liver and spleen by their immobility and lack of movement during respiration; this rule is not invariable, since not only wandering kidneys, but others when much enlarged, may be easily movable and follow the movements of the diaphragm.

Tumors of the stomach are often associated with gastric symptoms and

can be made to change their position by inflation of the organ with carbonic acid gas.

Tumors of the ovary usually lie immediately under the abdominal wall, while those of the kidney are separated from it by the colon and loops of intestine. Yet neither of these rules is absolute ; coils of intestine sometimes intervene between an ovarian tumor and the abdominal wall, and in two recorded instances of cancer affecting wandering kidneys, the renal tumor was located in front of the intestine. Reliance must be placed largely upon the history—displacement of the uterus, irregularity in menstruation, etc., indicating an ovarian growth, while hæmaturia and other urinary symptoms suggest the renal origin of the tumor. Fluctuation and the original position of the growth may furnish additional information ; and aspiration will usually decide the question definitely.

Psoas and perinephritic abscesses can generally be distinguished by the history, age, and appearance of the patient as well as by the peculiar position of the lower extremities of the affected side. They do not extend so high and have been at some period accompanied with fever.

Caseous enlargement of retroperitoneal glands may present a tumor whose physical characters simulate those of renal cancer; a distinction can usually be made from the history and from the urinary appearances.

Impaction of fæces in the colon has been repeatedly mistaken for renal cancer. The consistence of these masses, their mobility and coincidence with the outline of the intestine, suffice for making a distinction. The history and the use of cathartics or copious injections will decide a doubtful case.

After it has been determined that a given tumor proceeds from the kidney, the nature of the growth is to be decided. This often requires aspiration of the tumor and a microscopic examination of its contents—a measure which should never be omitted in doubtful cases, and is less objectionable in cases of renal cancer than of hydronephrosis (with which the former can scarcely be confounded). Particles of tissue which render the diagnosis positive have been obtained in this way.

Various unusual conditions may simulate cancer of the kidney. One of the most remarkable of these which has ever come under my notice was an unpublished case observed in the Vienna General Hospital in the service of Professor Dittel. A woman of advanced years presented a tumor which occupied the right hypogastric and iliac regions and could be plainly felt through the thin abdominal wall as a hard mass, sensitive to pressure and immovable. The patient had experienced much pain in this region, radiating down the thighs and across the abdomen ; emaciation had been pronounced for several months. The urine contained a small quantity of albumen, but no other abnormal ingredient. At the time of admission to the hospital, the patient was almost dead from exhaustion, and begged for any operation that would either remove the offending object or end her life. The diagnosis was made of renal tumor, probably malignant, and an operation for its removal reluctantly undertaken.

The tumor proved to be a mass about eight inches long, and five inches thick, surrounded by a fibrous capsule ; upon incising this capsule, a second of similar appearance came into view. An incision through this second capsule disclosed a highly vascular tissue which bled freely upon every contact of the finger or instrument. The interior of the mass consisted of a cheesy material, the central part of which was liquefied. The attempt at removal was abandoned on account of the hemorrhage as well as the dangerous exhaustion of the patient. At the autopsy, three days later, it was

found that this mass had no connection whatsoever with the kidney, which was found in position, greatly flattened and compressed, behind the tumor. The latter had been developed in the sheath of one of the lumbar nerves, and could be traced up to its entrance into the spinal column.

Prognosis.—Cancer of the kidney which does not permit surgical interference is always fatal, sometimes in a few months, perhaps only after many years; the fatal result occurs earlier in children than in adults. It should be remembered that the diagnosis is frequently uncertain and that the prognosis should be correspondingly undecided.

Treatment.—The medical treatment is entirely symptomatic; pain should be relieved by the free use of anodynes and hot fomentations over the loin; profuse renal hemorrhage may be arrested by cold applications over the kidney, rest in bed, gallic acid, or ergot. Clots of considerable size, which cause retention by obstructing the urethra, may be displaced by the catheter and broken up by injections of warm water with or without pepsine.

In recent years the possibility of radical cure by extirpation has been demonstrated in isolated cases by Czerny, Martin, Barker, Langenbuch, and others. Bruntzel removed a fibroma of the kidney weighing thirty-six pounds; and Lossen even extirpated an immense angiosarcoma in a pregnant woman, with entire success. These cases are as yet too few to permit a positive opinion as to the utility and safety of the operation; it would certainly be unadvisable in cases where the size of the growth would indicate that the neoplasm had involved perinephritic tissues and had produced metastases; and it would be less promising in young children, in whom both kidneys are often affected by congenital neoplasms. The chances are regarded as most favorable when the growth involves a wandering kidney in an adult.

Hydatids of the Kidney.

Various nematode and cestode worms parasitic in the human and other animals attain their development in successive stages, which may be passed in different animal hosts. The tænia echinococcus is found in its mature state as the common tapeworm of the dog's intestine. The eggs of this animal are discharged with the fæces and may be taken into the alimentary canal of a second host. Thence the parasite makes its way to various abdominal and thoracic organs and develops into the so-called hydatid cysts.

In man these hydatids are not rare, though they are less frequently found in the kidneys than in the liver and lung; in three hundred and sixty-six cases Davaine found these cysts in the kidneys thirty-three times. They may be formed at any period of life, most frequently between twenty and forty years of age; and are observed oftener in males than in females.

Morbid Anatomy.—As a rule but one kidney is affected, the left more frequently than the right. The cyst consists of a mother-sac, within which are contained numerous smaller vesicles (daughter-sacs) floating in a watery fluid. These vary much in size, the largest containing a third generation (granddaughter-sacs). In rare cases the original sac is the only one present, containing nothing but fluid contents. On the inner wall of each sac are found groups of echinococci, each just large enough to be visible to the naked eye, and each provided with four suckers and a double row of hooks.

The cysts vary in size from that of a bean to the dimensions of an adult head. The mother-cyst does not as a rule occupy the entire organ, portions of the parenchyma remaining around it; this renal substance is usually in a state of inflammation or fatty degeneration; extravasations of blood around the cyst are frequent. As a rule but one mother-cyst is found, though numerous smaller ones are sometimes seen scattered through the renal tissue. The other kidney is usually hypertrophied. After the tumor has attained such size as to compress adjacent organs, adhesions occur, binding the kidney to the neighboring tissues. In the fluid contents of the cyst are found cholesterine and urinary constituents, particularly uric acid and phosphates; an excess of sodium chloride—more than is contained in any other cyst—is a characteristic feature. The fluid contains at most a trace of albumen, frequently none; and has a specific gravity of 1.008 to 1.015.

The cysts may remain stationary for years and then suddenly increase in size; or the organisms may perish and atrophy of the cyst follow. In this case the fluid is absorbed and the sac contracts into a firm mass containing calcareous concretions and fat. The dangers attendant upon them are due to pressure upon and adhesions to neighboring organs, suppuration in and around the cyst, bursting of the cyst into the intestine, stomach, lung, or peritoneum.

Symptoms.—Echinococci of the kidney rarely attract attention until a perceptible tumor has been produced or perforation occurs. Sometimes obscure symptoms caused by the pressure or adhesion of the tumor to surrounding organs are the first indications of their existence. Even after a tumor is discovered, its nature may long remain unknown. Its connection with the kidney can often be determined by the considerations advanced in discussing the diagnosis of renal cancer; but the probabilities are that the enlargement is due to some other cause than the echinococcus. Fluctuation is a frequent, but by no means constant, feature; in some instances a peculiar sensation—the "hydatid thrill"—caused by the collision of the cysts enclosed in the mother-sac, is communicated to the finger upon palpation. This thrill is a comparatively rare symptom, and is moreover not characteristic of hydatids, since it has been elicited in cases of hydronephrosis. The tumor is often painless, or it may cause some pain by pressure upon adjacent nerves.

Characteristic symptoms occur when the cysts burst and discharge their contents into the renal pelvis, an occurrence noted in about two-thirds of the cases already recorded. The rupture of the sac is often provoked by violence, a blow or fall upon the back, or rough riding; it may happen in an individual who has never been suspected of harboring the parasite. Sharp pains and a feeling as if something had given way usually occur, and are followed by the symptoms of renal colic, caused by the passage of the cystic contents through the ureters. Pain in the loin and along the ureters, with or without chill, vomiting, and fever indicate the passage of the cysts. These symptoms may subside suddenly so soon as the sacs have entered the bladder, after which frequent and painful urination follows.

The rupture of the cyst is followed by characteristic appearances in the urine, usually before the indications of obstructions in the ureters are experienced. The urine presents a milky appearance and contains numerous oil-drops, fragments of tissue, shreds of the lining membrane of the sac, and hooklets from the echinococci. The appearance of these hooklets or membrane (Fig. 17) is the only positive factor in diagnosis.

After the sacs have reached the bladder sudden retention of the urine may occur from the obstruction of the urethra; the introduction of the catheter has in a few instances served to remove cysts from the bladder; women have been known to extract these bodies from the urethra with the finger; in other cases the pressure of the vesical wall has been sufficient to rupture the cyst, sometimes with a loud noise, followed by the escape of gas and liquid. Entire cysts are passed through the urethra in the male as well as in the female. The urine usually contains albumen and blood.

The attack may cease in a few hours; but there may remain other cysts which increase in size and subsequently rupture, occasioning a repetition of these phenomena. The subsequent attacks may happen at intervals of hours or years.

Fig. 17.—Echinococcus Membrane and Hooklets.

In some instances the contents of the cysts have remained in the pelvis of the kidney, constituting a permanent obstruction and inducing hydronephrosis; or they may remain in the bladder and excite cystitis.

The complete expulsion of the cystic contents may be followed by spontaneous recovery; the sac and the kidney shrivel and atrophy, or the sac alone may be transformed into a shrunken, cheesy mass, while the kidney continues to perform its functions. Extensive suppuration in and around the sac has occasionally caused pyæmia; chronic pyelitis is another possible sequel. The hooks may escape in other ways than with the urine; they arrive in the stomach and are vomited; or they reach the intestine and are passed with the fæces; they may escape through the diaphragm into the lung and be expectorated; perforation through the muscles and skin of the loin has also occurred.

After the expulsion of hydatid cysts of the kidney, long intervals of perfect health may follow and yet repetitions occur; indeed, it is impossible to assert that no cysts remain.

Diagnosis.—A positive diagnosis of renal hydatids can be based only upon the discovery of the parasite or of the peculiarly stratified membranes in the subject of a renal tumor. The presence of hooks in the urine does not necessarily locate the cyst in the kidney, since hydatids situated in the pelvic tissues have been known to escape into the urinary passages and be discharged with the urine. If the parasites present have escaped from the kidney, a diminution of the renal tumor is observed to coincide with their appearance in the urine. If no echinococci are found in the urine, the tumor may be confounded with hydronephrosis or ovarian cyst; if a distinction be impossible from the history and physical peculiarities (see diagnosis of renal cancer) aspiration of the tumor and examination of its contents should be made. Even if no hooklets nor bladders are discovered, an excess of common salt and absence of albumen afford presumptive evidence of the hydatid origin of the cyst.

A general absence of constitutional symptoms and of urinary abnormalities characterize hydatid cysts of the kidney previous to their rupture.

Treatment.—During the passage of cysts down the ureter, the measures employed for renal colic are indicated. Morphine, warm baths, gentle friction along the ureter, and rest in bed should be directed. The irritation caused by the presence of the cysts in the bladder has sometimes been relieved by the introduction of the catheter, in the eye of which the sacs have become entangled.

The radical cure of renal hydatids has been often attempted, but seldom accomplished. Simple evacuation through a trocar has in a few instances been followed by recovery; the injection of iodine, electrolysis, incisions, have been employed with more or less success, but are not devoid of danger.

Renal Cysts.

Cysts are developed in the kidney both before and after birth. The former result from congenital malformations, while the latter appear to be produced by inflammatory affections.

Congenital cysts of the kidney may be found in one or both organs, and are usually multiple. At times they occupy the entire capsule, leaving only fragments of renal substance. The organ is much enlarged, sometimes attaining enormous dimensions, filling the abdomen, preventing the delivery of the fœtus, and rendering embryotomy necessary.

The reason for this retention of the renal secretion and distention of the urinary channels is in many cases a congenital obstruction in the urinary passages. These are chiefly intra-renal impediments—uric acid concretions in the tubules, consecutive inflammation closing the straight tubules (Virchow), an imperforate condition of these tubules from lack of development; the latter is insisted upon by Kupfer, who asserts that the urinary tubules and the pelvis of the kidney are developed independently of each other, and that there may be a congenital failure to establish communication between them. Obstructions in the lower urinary passages seem sometimes to cause renal cysts as well as hydronephrosis; among these are contracted phimosis and valvular folds in the ureter. In some instances renal cysts have been developed without discoverable cause. The contents of these cysts are an albuminous fluid containing carbonates, phosphates, and other urinary ingredients, especially the urates; sometimes the fluid is quite thick and gelatinous.

Congenital cysts of the kidney have been repeatedly noticed in infants

presenting other malformations, such as hydrocephalus, cleft palate, supernumerary fingers, etc. ; and it has been observed that several children exhibiting congenital renal cysts have been borne by the same mother.

Cysts developed during extra-uterine life originate in local obstructions of individual tubules by concretions of uric acid or other urinary ingredient, but especially by increase of connective tissue during chronic nephritis. These cysts are usually very small, and occasion no recognizable symptoms during life ; they are especially frequent in contracted kidneys.

A few instances are recorded in which complete cystic degeneration of both kidneys has occurred in adults. The origin of these cysts is unknown. Cardiac hypertrophy—resulting probably from the accompanying renal atrophy—is often seen.

The diagnosis of renal cysts can be made only when an appreciable tumor is present, and then only after puncture and examination of the contents. Such cysts have been mistaken for hydronephrosis, distended gall-bladder, hydatids, etc. Hæmaturia, albuminuria, and uræmia have been observed in cases of extensive cystic degeneration; the urine may be normal except that its specific gravity is low in advanced stages. Compression of the abdominal and even thoracic organs and rupture of the cyst into the peritoneal cavity are possible complications.

Perinephritis.

The kidney is imbedded in loose connective tissue whose meshes contain a certain quantity of fat, which is continuous with the connective tissue of the pelvis ; hence an inflammatory process in the one locality may spread by continuity into the other.

Perinephritis is often acute and usually secondary to inflammation elsewhere. A primary inflammation seems to be sometimes produced by exposure to cold, violent muscular effort, riding over rough roads, injuries to the loins, and direct wounds of the kidney. Secondary perinephritis is usually produced by an extension of a pre-existing inflammation—of the kidney itself, of the mucous membrane of the renal pelvis, or of the pelvic viscera and connective tissue ; it occurs, therefore, as a complication of chronic nephritis, pyelitis, cysts, abscesses, infarcts, and cancer of the kidney ; it is seen after operations upon the pelvic organs—the rectum, bladder, or uterus, lithotomy and perineal urethrotomy, pelvic cellulitis—and is hence an occasional complication of the puerperal state. It has been caused by inflammation of the duodenum and gall-bladder. It is produced also by the extension of an inflammation along the spinal column, in or behind the peritoneum or even above the diaphragm—spinal caries, perityphlitis, peritonitis, abscess of the liver and spleen. The perinephritis which occurs in the course of certain infectious diseases, especially small-pox, typhoid and puerperal fevers, and pyæmia, seems to be caused by extension from an inflammatory process in the kidney or its pelvis.

It is worthy of note that diseases of the male genital organs, especially the testes and the spermatic cord, seem especially prone to the production of pelvic and secondary perinephritic inflammations. Chopart observed a case in which perinephritis seemed to be caused by simple excision of a testicle ; suppurative inflammation of the spermatic cord following gonorrhœa has produced the same result ; even chronic catarrh of the bladder following urethral stricture or prostatic enlargement may induce perinephritis. The inflammatory process extends along the mucous mem-

brane to the pelvis of the kidney and then invades the surrounding connective tissue; or the pericystic tissue becomes the seat of an inflammation which is then propagated behind the peritoneum as high as the kidney. Perinephritis may thus follow the incautious use of the catheter in cases of habitually distended bladders.

This disease affects males more frequently than females, and is usually, though not exclusively, observed in adults; it is almost invariably unilateral.

Morbid Anatomy.—This consists in the signs of diffuse inflammation, often proceeding to suppuration; in some instances localized and circumscribed abscesses are found. The perinephritic fat is usually absent and the kidney often floats in a mass of pus. This pus, like that which forms around the bladder in cases of pericystitis, may exhale a decidedly fecal odor, although no communication with the intestine exist.

The pus is rarely confined to the immediate vicinity of the kidney; it commonly burrows into neighboring tissues, infiltrating the muscles and making an exit through the skin of the loins, under Poupart's ligament, or into the scrotum or perineum. More frequently the pus perforates into the peritoneal cavity, the intestine, stomach, vagina, or bladder; it has been known to reach the gluteal muscles and even to burst into the hip-joint. Sometimes a perinephritic abscess has perforated the diaphragm and emptied into the pleural cavity or into the bronchial tubes. The presence of this pus excites inflammation in the tissues which it reaches and thus causes peritonitis and erosion of the spinal column and psoas abscess. Pleurisy, pericarditis, pylephlebitis have also been observed as the result of perinephritic inflammation.

In a few rare cases the pus is either absorbed or undergoes cheesy degeneration; the inflammation may result in the formation of cicatricial tissue around the kidney, whereby atrophy of this organ is induced.

Symptoms.—Primary perinephritis is usually indicated by acute and pronounced symptoms—chill or repeated chills, fever, usually of an intermittent character, pain in the loins and the usual accompaniments of a febrile condition, loss of appetite, nausea, vomiting, and constipation.

Secondary perinephritis often begins with the same symptoms, but in cases of gradual extension of an inflammatory process there may occur no pronounced symptoms. In such cases there may be no suspicion of perinephritic inflammation until pain, swelling, and tenderness in the region of the kidney direct attention to this part of the body. Fever is an almost constant symptom, though its grade varies extremely. Sometimes the febrile movement exhibits such regular intermissions as to lead to a diagnosis of malarial fever. After suppuration has begun there occurs, as in other cases of internal suppuration, a series of chills suggestive of pyæmia. The escape of pus externally or into one of the internal organs or cavities is marked by the sudden cessation of the febrile movement as well as of the chills. In cases of extensive inflammation the patient may lapse into a typhoid condition.

Pain is another constant and important symptom. It is sometimes continuous, at others of an intermittent character, suggesting lumbago or neuralgia. The pain is usually felt over the region of the kidney, but may radiate into the groin and even down the thigh; the lower extremity may exhibit impairment of power or of sensation, and in a few cases it has been observed that the range of motion was circumscribed precisely as in inflammation of the hip-joint. The distinction can be made, however, by the fact that in perinephritis pressure in the lumbar region increases the pain, while pressure upon the hip does not.

Swelling becomes perceptible sooner or later in the course of the disease. It does not usually take the form of a pronounced tumor, but can be detected upon comparison of the two sides; the loin is broader and full, the skin is tense, shining, perhaps reddened, and often œdematous. By placing one hand upon the lumbar region over the kidney and pressing with the other upon the abdominal wall in front of the organ, a feeling of tenseness and resistance can be discovered which is absent when the same manœuvre is repeated on the opposite side.

If the pus approach the surface near the spinal column, there is often observed a slight lateral curvature of the spine, the concavity directed toward the diseased side. The patient experiences pain upon standing or walking, and carefully avoids all movement which requires contraction of the abdominal muscles. The interference with the movements of the diaphragm may occasion dyspnœa. Compression of the colon may cause obstinate constipation; the fecal masses can quite obscure the tumor, which may be therefore overlooked.

The urine is not necessarily changed by this inflammation; the primary affection, such as pyelitis or suppurative nephritis, is of course indicated by characteristic changes. It occasionally happens that the pus from the perinephritic abscess bursts into the pelvis of the kidney and appears with the urine.

Other symptoms depend upon the extension of the inflammation to neighboring organs. Escape of the pus into the stomach or duodenum is followed by purulent vomiting; into the large intestine by an admixture of pus with the stools. Perforation of the diaphragm into the lung tissue occasions the expectoration of pus or perhaps even suffocation; perforation into the pleural cavity causes pleurisy and pyothorax. Curious anomalies in the course of the pus have been observed: thus Trousseau described two cases in which emphysema of the skin occurred, due to the presence of gas from the intestine into which the pus had emptied. Such communication with the intestine may also cause the appearance of fæces in the abscess and subsequent gangrene.

Diagnosis.—The recognition of perinephritis is often difficult or even impossible until swelling and fluctuation in the loin become apparent. When this symptom coexists with fever and pain over the kidney, without abnormality of the urine, the diagnosis is clear. Unfortunately one or more of these diagnostic conditions may be absent or obscure; there is then a possibility of confusion with several other conditions.

Other tumors of the kidney—cancer, hydatids, cysts, hydronephrosis, and tuberculosis—cause an enlargement perceptible through the abdominal wall without producing appreciable swelling in the loin; while the perinephritic tumor is most pronounced posteriorly. Moreover, these affections are not as a rule accompanied with pain and fever; and in several of them characteristic appearances are observed in the urine.

Pyelitis and pyelonephritis can usually be distinguished from perinephritis by the condition of the urine; yet they are frequently complicated by perinephritic inflammation.

Abscess in the psoas muscle and around the hip-joint may be mistaken for perinephritis, since the latter condition may furnish one of the characteristic symptoms of the two former—the restricted range of movement of the lower extremity and the pain attending its motion. Yet in perinephritic inflammation there is always extreme tenderness upon pressure in the loin, a symptom which is absent in the other affections named; moreover, in perinephritis the patient permits complete flexion of the limb

without complaint, a movement which causes pain in either of the other morbid conditions. Tenderness upon pressure over the hip-joint or at some point along the spine may be found in coxitis or spinal caries, but is absent in perinephritis.

Perityphlitis may present the three prominent symptoms of perinephritis—fever, pain, and swelling; but the tumor is situated lower in the abdomen, the pain is not felt upon pressure over the kidney, and the attendant symptoms are those of intestinal obstruction, including an excess of indican in the urine.

Perinephritis is in the early stages often considered lumbago or rheumatism; it is distinguished from these by the accompanying fever.

CHAPTER XIX.

DISEASES OF THE BLADDER.

Cystitis.

Etiology.—Inflammation of the bladder is one of the most frequent affections of the urinary organs after puberty. It is extremely important to recognize the fact that cystitis is almost invariably secondary to some previous morbid process; it is indeed a *symptom*, the origin of which should always be sought before treatment is undertaken, since this varies according to the cause of the cystitis.

The causes of vesical inflammation are numerous, but are usually to be sought in present or previous affections of other urinary organs. In this connection Ultzmann emphasizes the clinical fact that cystitis is extremely rare previous to puberty, except as it results from mechanical irritation by calculi or instruments. It is almost exclusively after puberty, when the genital organs are exposed to sexual abuse and disease, and the kidneys suffer from excesses in eating and drinking, that cystitis results.

Among the most usual causes of cystitis may be mentioned:

Mechanical irritation; this proceeds from the presence of a stone or tumor in the bladder, from the use of instruments in the bladder, urethra, vagina, or rectum; from pressure during delivery; from pressure caused by pessaries or pelvic tumors; it is even possible that obstinate constipation is responsible for some cases.

Irritation may also be produced by the entrance of *drugs* into the bladder, either by excretion with the urine or by injection from the urethra. The excessive use of copaiba and cubebs in the treatment of gonorrhœa should be avoided, since these substances, as well as cantharides, turpentine, Peruvian balsam, etc., are in themselves sufficient to produce irritation and inflammation of healthy kidneys and bladder, and must certainly increase the danger of an extension of the inflammation to the bladder during a gonorrhœa. Some individuals are so susceptible in this respect that the simple application of a small cantharides plaster on any part of the skin is sufficient to cause vesical irritation.

Certain *articles of food* produce in many individuals a decided irritation of the bladder; such are ill-fermented beer, sour wines, and asparagus; extreme acidity of the urine favors vesical inflammation when a predisposition exists.

Cystitis arises frequently by *extension of an inflammation* affecting an adjacent tissue; thus it is seen as a complication of gonorrhœa, prostatitis, inflammation of the uterus, of the pelvic connective tissue, the rectum, the ovaries, and the renal pelvis. It is also a frequent phenomenon in various *infectious diseases*, such as pyæmia, variola, typhoid fever,

and acute rheumatism. Doubtless in some of these cases the cystitis is produced not by the specific infection, but indirectly by the mental condition of the patient, which leads to retention of urine and renders catheterization necessary.

The cystitis which usually occurs sooner or later in cases of paraplegia, is generally caused by the consequent retention of urine and introduction of unclean catheters; though Charcot is inclined to assume for these cases of nervous disease and injury the possibility of a trophic inflammation of the bladder, originating, like the familiar herpes zoster, in a disturbance of nervous influence.

Simple *retention of the urine*, either acute or chronic, may induce an inflammation of the vesical mucous membrane. In cases of prostatic enlargement and tight urethral stricture, resulting in habitual distention of the bladder, a mild grade of cystitis is a regular feature, manifested by the turbidity of the urine (found under the microscope to be caused chiefly by pus and proliferating epithelium) and by frequent, sometimes painful urination. If no instrument be introduced into the bladder, the cystitis from habitual retention of urine rarely attains the most acute form or exhibits the ammoniacal fermentation. The first introduction of a catheter for the relief of this condition is, however, frequently followed by ammoniacal fermentation and a most violent cystitis. The disastrous effects of catheterization under these circumstances have been already discussed under the head of Urethral Fever. They are attributable to one or both of two factors: the use of unclean instruments, whereby ferment-producing agents are introduced into the stagnant urine; and the sudden relief of an habitual distention, whereby an intense congestion of the vesical mucous membrane is produced. Stagnant urine when protected from atmospheric organisms does not undergo that fermentation whereby urea is converted into carbonate of ammonia; this has been amply demonstrated by Cohnheim and Leube. Bacteria introduced into a healthy bladder which is capable of complete evacuation are expelled at once with the urine, and even if they remain would find no material for fermentation. When, however, both conditions are given—stagnant urine in a bladder which is prevented by prostatic hypertrophy or urethral stricture from complete contraction, and bacteria introduced by means of unclean instruments—the ammoniacal fermentation occurs at once, producing a violent cystitis. Even in these cases the urine may be of acid reaction when it enters the bladder from the ureters, as was demonstrated by Ultzmann; but as there is usually distention and stagnation of urine in the ureters and pelves as well, the fermentation and consequent inflammation commonly extend to the kidney at least, producing those intractable cases of cysto-pyelitis, or cysto-pyelo-nephritis.

In this connection it should be stated that an experiment of Aufrecht indicates that ammoniacal fermentation of urine can occur in a healthy bladder from simple retention. This observer closed tightly with adhesive plaster the prepuce of a rabbit so as to prevent completely the escape of urine; at the autopsy several days later the urine was found to be bloody and ammoniacal, and the mucous membrane of the bladder exhibited the appearances of diphtheritic inflammation. The ammoniacal fermentation certainly can occur in human subjects previous to the introduction of instruments; this has been repeatedly observed in cases of paralysis of the bladder from paraplegia and less frequently in the habitual retention of urine from prostatic enlargement.

Certain *constitutional taints* favor the development of and possibly pro-

duce cystitis. In scrofulous individuals there is a tendency to catarrh of mucous membranes generally; the subjects of tuberculosis are especially prone to vesical catarrh, in many instances without the actual occurrence of the tuberculous inflammation in the bladder itself. English authors speak of a "gouty cystitis," with reference to which Sir Henry Thompson says: "Possibly you may be forced to attribute it to a gouty diathesis. A very refuge in time of trouble for practitioners of feeble diagnostic power is gout, particularly 'suppressed gout;' therefore beware of it. And while I think it must be admitted that inflammation, either of the urethra or of the bladder, may be sometimes a mere local development of the ubiquitous influence so named, I am sure that this cause is of exceedingly rare occurrence."

Cystitis frequently appears immediately after exposure to cold and moisture, and *apparently* as the result of such exposure; yet in many such cases careful inquiry elicits a history of gonorrhœa, gleet, chronic prostatitis, stricture, retention of urine, etc. It is certain that exposure to cold rarely induces cystitis in childhood; yet it is a possibility that such result may follow in adult life, even in the absence of predisposing influences in the shape of previous gonorrhœa.

In rare cases no exciting cause for an observed cystitis has been detected.

Morbid Anatomy.—The anatomical appearances vary according as the inflammation is acute or chronic, partial or complete, as well as according to the cause.

An inflammation resulting from extension of a gonorrhœa is often limited to the so-called neck of the bladder, including the trigonum, where are located most of the glands of the vesical mucous membrane. This portion of the surface is reddened, thickened, and usually covered with mucus.

Acute inflammation of the entire mucous membrane causes an intense swelling and softening of the membrane, which is marked here and there by extravasations of blood. The surface is covered with a muco-purulent layer; the muscular and connective-tissue coats are often swollen and soft. If there has been habitual retention of urine, the cystitis having been provoked by the use of a catheter, the muscular coat is hypertrophied, and frequently contains minute abscesses; the perivesical tissue is also inflamed and may be the seat of suppuration.

In chronic cystitis there is observed a general enlargement of blood-vessels, especially of the veins around the neck of the bladder. The muscular as well as the mucous coat is usually thickened and frequently softer than normal. The surface is of a gray or reddish-brown color, covered with pus and mucus, in which urinary salts, especially the phosphates, are thickly embedded; local ulcerations and erosions are observed, chiefly in the neighborhood of the trigonum. The inflammation may involve the entire vesical wall and the perivesical tissue, constituting the so-called interstitial or phlegmonous cystitis. The entire tissue is honeycombed with pus and often gangrenous in spots. It may emit a fecal odor, even though no communication with the intestine exist. Perforation of pericystic abscesses may occur into the vagina, rectum, peritoneum, or bladder.

The superficial necrosis of the mucous membrane frequently misleads into the diagnosis of a diphtheritic inflammation. This necrosis is a regular feature of cystitis with ammoniacal fermentation of urine; and in certain cases, especially in the cystitis of the puerperal state and in that following gynecological operations, the entire mucous membrane becomes necrotic and is cast off, leaving the muscular coat bare; indeed, this may also be-

come gangrenous. It has recently been demonstrated that a gangrenous cystitis, including the exfoliation of the mucous membrane, is a not infrequent result of pressure by a retroflexed gravid uterus.

The explanation of the obstinacy of a cystitis is sometimes found post-mortem in the existence of one or more diverticula, protrusions of the mucous membranes between muscular bundles. These usually occur in those cases in which there has been some impediment to the evacuation of the bladder; they contain masses of pus, urinary salts, and sometimes well-formed calculi. Adhesions of the bladder to surrounding organs are usual; these may prevent the complete evacuation or expansion of the organ, and thus complicate the clinical symptoms and vitiate therapeutic measures.

The bladder is sometimes found much distended, at other times contracted. The former condition, accompanied with thickening of the muscular coat, is termed eccentric hypertrophy; the latter, concentric hypertrophy. A strongly contracted bladder, without actual increase in the thickness of the muscular coat, is sometimes mistaken post-mortem as well as during life for concentric hypertrophy.

Symptoms.—These vary with the degree and extent of the inflammation. Cystitis affecting only the neck of the bladder, and resulting from the extension of a gonorrhœa, or from the awkward and violent use of instruments in the bladder, may be indicated only by undue frequency and some pain in urination, by a constant, dull, aching pain above the symphysis, and by a slight cloudiness of the urine; occasionally a little febrile action is observed.

Acute inflammation involving the entire mucous membrane often begins with a chill, followed by high fever; yet cases occur in which chilly sensations alone mark the beginning of the attack. Two subjective symptoms are constantly present: a constant desire to urinate, and pain around the neck of the bladder. The pain is often felt also near the end of the penis, in the perineum, in the groin, and over the sacrum; it may radiate into the thighs and testicles. Concentration of the pain in the perineum indicates especial intensity of the inflammation at the neck of the bladder and trigonum. There is tenderness upon pressure over the bladder, and the abdomen is often somewhat distended.

The constant and painful straining to evacuate the bladder (vesical tenesmus) is a most prominent symptom. This is induced by the abnormal irritation of the sensory nerves in the mucous membrane at the vesical neck. For in the normal condition the desire to evacuate the bladder originates in irritation of these nerves caused by the pressure and distention due to the contained urine; in the inflammatory state there is a constant irritation of these nervous filaments, and therefore a constant reflex spasm of the detrusor muscles and desire to urinate, even when the bladder is quite empty. The compression of the swollen and inflamed mucous membrane by this constant contraction induces the pain. Usually the bladder is kept practically empty, no time being allowed between the expulsive acts for the accumulation of urine. Sometimes, however, there is a similar spasm of the vesical sphincters (including the membranous urethra); in this case there is a constant strife between the detrusors and the sphincters, resulting in the retention of more or less urine, and in a corresponding increase of the pain and straining. In comparatively rare cases this spasm of the sphincters, reinforced by an inflammatory swelling of the mucous membrane at the urethral orifice of the bladder, occasions complete retention of urine, requiring the use of the catheter. Such re-

tention is especially observed in subjects who do not confine themselves to the house or the bed; and it is accordingly seen in individuals in whom a cystitis arises during the course of a gonorrhœa. Rectal tenesmus sometimes complicates cystitis; in every case defecation is painful because of the pressure of the fæces upon the bladder-neck and prostate. Occasionally the patient is tormented with priapism.

The *symptoms of chronic cystitis* are identical in kind with those of the acute inflammation, but are usually far less intense. The most prominent feature is the frequent and painful urination; the pain during the act as well as in the intervals is less severe and may even be absent. The intensity of the symptoms varies greatly independently of treatment; they are increased in severity by bodily exertion, excesses in eating, drinking, and venery, exposure to cold, obstinate constipation, etc.; and improve in the absence of such excesses and usually during warm weather. Sudden retention of urine followed by an exacerbation of the complaint is apt to occur, especially when the cystitis is the result of prostatic enlargement or urethral stricture.

The urine affords most positive information as to the existence, and often as to the cause, of cystitis, acute or chronic. The urinary characteristics vary with the degree, duration, and origin of the affection. Previous to the development of the fermentation whereby urea is converted into carbonate of ammonia, the urine is often of unusual acidity, somewhat turbid, and deposits a sediment which consists of epithelial cells, pus, and blood-corpuscles; bacteria are present in large numbers even while the urine remains acid (Fig. 18). It is worthy of note that during cystitis the urine is extremely prone to the ammoniacal fermentation outside of the body; this change may occur within twenty or thirty minutes after evacuation; hence it is important to observe the reaction of the freshly voided urine before assuming that this fermentation is occurring in the bladder. In nearly all cases the microscope reveals blood-corpuscles in the sediment; in many instances the quantity of blood is so great as to be readily appreciable to the naked eye.

FIG. 18.—Sediment from Acute Cystitis, Urine Acid.

So soon as the ammoniacal fermentation of urea occurs within the bladder, the characters of the urine as well as the subjective symptoms undergo a change. The additional irritation caused by the ammoniacal compounds produces increased suppuration; while under the influence of these compounds the pus is transformed into thick, slimy masses, usually designated "mucus." The pronounced alkalinity of the urine causes the precipitation of urinary salts in large quantity; the sediment is therefore more abundant and the urine more turbid. In the sediment (Fig. 19) is a profusion of beautiful large, colorless, coffin-lid crystals of ammonio-magnesium (triple) phosphate; of dark brown balls and dumb-bells, often provided with thorn-like spicules—ammonium urate; and a mass of amorphous granules, composed chiefly of the carbonate and phosphate of calcium and magnesium. At this stage blood-corpuscles and epithelial cells are numerous; the pus-corpuscles are largely transformed into the jelly-

like mass already mentioned. The urine swarms with bacteria in active motion.

All symptoms are much aggravated by the development of the ammoniacal fermentation in the bladder ; moreover, the viscid masses of transformed pus (mucus) sometimes cause mechanically a retention of urine by obstructing the urethral orifice, rendering the use of a catheter necessary. In diphtheritic inflammation as well as in that form induced by cantharides, plugs of fibrin may be formed and produce a similar obstruction to the exit of the urine. Actual exfoliation of the vesical mucous membrane

FIG. 19.—Sediment from Acute Cystitis after Ammoniacal Fermentation of the Urine was established ; Epithelial Cells, Swollen Leucocytes, Prismatic Crystals of Triple Phosphate, Spherical Spiculated Masses of Ammonium Urate, and Bacteria.

sometimes occurs, particularly during retroflexion of the gravid uterus, though sometimes from a diphtheritic or an intense catarrhal inflammation ; Lister records a case of traumatic origin. The exfoliated membrane is usually so incrusted with urinary salts as to be indistinguishable from masses of fibrin ; sometimes the structure can be distinctly recognized with the microscope, as in an instance recorded by Krukenberg. Buchanan observed a case in which exfoliation of the mucous membrane completely relieved a sixty-year-old man from a long and obstinate cystitis.

Course and Complications.—These depend largely upon the cause of the vesical inflammation. A simple acute cystitis usually terminates favorably in ten days or two weeks ; yet in many instances the cause can be but partially removed, and in this case the course of the cystitis is far less satisfactory. Inflammation of the neck of the bladder following gonorrhœa is extremely apt to recur long after the urethral inflammation has subsided. The least exposure to cold, overindulgence in the pleasures of the table, sexual excess, etc., may induce an obstinate attack ; and frequent repetitions culminate in a chronic catarrhal condition.

Among the many complications of acute cystitis is the extension of the inflammation to the muscular and external coats of the bladder. This is indicated by incomplete evacuation, dribbling of urine, but especially by a fecal odor of the urine due to the diffusion of gases from the intestine through the inflamed bladder-wall. The formation of pus in the substance of the organ is indicated by chills, high febrile movement, and the occurrence of typhoid symptoms. The closure of the orifices of the ureters may cause complete anuria and uræmia. Perforation of pus may take place into the pericystic tissue, into the rectum, vagina, bladder, or perineum; sometimes complete perforation of the vesical wall, followed by urinary infiltration, occurs.

Retention of urine either by the lodgment of fragments of membrane, pieces of fibrin or masses of pus in the urethral orifice, by spasm of the sphincter or from other cause, is usually relieved without difficulty by the catheter, if discovered; but as the patient passes only a few drops of urine at a time, both he and his physician are apt to overlook a complete retention. Such retention may have serious results; for rupture of the bladder occurs far more readily than in the normal condition, especially if the inflammation involve also the muscular coat; moreover, distention lasting only a few hours may be sufficient to cause permanent atony of the organ, a condition which, as is well known, can be produced in a normal bladder by voluntary retention of urine. Hence the physician should by daily palpation satisfy himself that the urine is not retained.

Acute cystitis is frequently complicated by pyelitis, commonly in those cases in which there has long existed an impediment to the escape of urine, and consequent distention of bladder, ureters, and pelves. Pericystitis is an occasional sequel, and may result in the formation of abscesses in the perineum, sometimes accompanied with urinary infiltration.

Chronic cystitis is commonly itself a complication, though its course is aggravated by pre-existing conditions; these are hypertrophy of the bladder, either excentric (with dilatation) or concentric (without dilatation). In the former case there is habitually some residual urine in the bladder, and diverticula frequently exist; the bladder is distensible; hence urination need not be frequent, but each act requires much time, since the urine is expelled slowly. Dribbling of urine is frequent; complete retention often aggravates the cystitis. In concentric hypertrophy there may also be some residual urine; but micturition is frequent and the stream usually strong; the urine occasionally dribbles between the acts of urination. This condition is often discovered only upon an attempt to wash out the bladder; the injection of even two or three ounces of fluid causes the patient extreme pain, and arouses a violent contraction whereby the injected fluid is expelled with great force.

Chronic cystitis, especially when complicated with pyelitis, causes gradual emaciation and debility; it is a frequent cause of stone-formation in the bladder. In a few cases communication is established with the intestine, causing the admixture of fæces and perhaps of gas with the urine. Uræmia is more frequently observed from chronic than from acute cystitis, because the renal pelvis and the kidney itself are usually involved in chronic inflammation.

Prognosis.—This depends almost exclusively upon the cause of the affection. If this cause be irremediable, even though in itself compatible with life, the prognosis must be unfavorable; for chronic cystitis, with its train of chronic pyelitis and nephritis, produces such emaciation, debility, and cachexia, as to exhaust the patient in the course of a few years or even

months. Generally speaking the acute justifies a more favorable prognosis than the chronic form; when it can be traced to pregnancy or exposure to cold, the prognosis is usually good. On the other hand, cystitis, whether acute or chronic, occurring in a patient who has long suffered from prostatic enlargement, urethral stricture, vesical calculi, or who is the subject of tuberculosis or myelitis, is unfavorable.

Diagnosis.—Acute cystitis can rarely be overlooked or mistaken for other affections; the pain, tenesmus, and features of the urine are pronounced and characteristic. Inflammation affecting only the neck of the bladder may be overlooked when it occurs during the course of a gonorrhœa. Such oversight may have serious consequences from the neglect of the patient to avoid exposure and exertion; it is therefore important to remember in treating gonorrhœa, that intense pain localized in the perineum and extreme vesical tenesmus indicate an inflammation of the bladder-neck. Croupous, diphtheritic, or gangrenous cystitis is indicated by the appearance of threads of tissue and by the frightful odor of the urine.

The extension of the inflammation to the substance of the bladder-wall (interstitial cystitis) and to the perivesical tissue, may be suspected if a doughy, exquisitely sensitive tumor in the location of the bladder be perceived from the rectum or vagina; also if irregular chills, fever, and extreme prostration mark the attack. Possible complication with pyelitis has been discussed in the appropriate chapter.

Chronic cystitis may long exist in old men with prostatic difficulties, without giving rise to pronounced subjective symptoms. Its existence may be inferred from the turbidity of the urine.

Spasm of the bladder without inflammation may cause frequent and painful urination; but the urine exhibits none of the abnormal features found during cystitis, unless the vesical irritability be caused by pyelitis. In this case the urine contains pus and blood, and a careful analysis of the symptoms is often necessary for a differential diagnosis. Long-continued spasmodic contractions of the bladder, produced by irritation of the urethra (stricture of large calibre, contracted meatus), may gradually produce cystitis and hypertrophy, even in children.

In recent years several cases have been reported, under the name of *bacteruria*, in which several of the symptoms of cystitis are present. Urination is frequent and somewhat painful; the urine is turbid from the presence of bacteria, and emits a most offensive odor. There is, however, no pus nor evidence of catarrh or ammoniacal fermentation; indeed, the urine preserves for an unusually long time an acid reaction. The affection lasts in intermittent intensity for years.

It should be remembered that vesical irritation without inflammation frequently masks various morbid conditions of other organs, the kidneys, uterus, and rectum. Even when accompanied with pus and blood in the urine, the symptoms may be caused by pyelitis without cystitis.

Treatment.—This is determined to a great extent by the cause; and it cannot be too often nor too emphatically maintained that cystitis is a symptom, a result, and not a primary affection. Moreover, if the conditions which may produce cystitis be kept in mind in the treatment of urinary affections, this complication can often be avoided; for it is certain that many cases are produced quite unnecessarily by the physician. Aside from the injudicious use of irritating drugs—copaiba in the treatment of gonorrhœa, etc.—cystitis is certainly produced by the use of the catheter. Unnecessary violence in the employment of catheters and sounds is probably responsible for vesical inflammation, though in comparatively rare

cases; but the sudden and complete evacuation of a habitually distended bladder, either by the introduction of the catheter in the beginning of "catheter life," or by the performance of lithotomy or the division of a tight stricture, is certainly responsible for many cases of violent cystitis. The use of surgically unclean catheters or sounds in bladders containing residual urine is another fruitful cause of cystitis and cysto-pyelitis. These factors in the production of the disease have been discussed at length in the chapter on Urethral Fever.

The discovery of the condition upon which the cystitis depends determines to a considerable extent the course of treatment to be adopted. Sometimes the cause is removable, when, for example, it is a calculus, benignant growth, or foreign body in the bladder; sometimes the rectification of an excessive acidity or alkalinity of the urine is of itself sufficient to repress a subacute cystitis; or the cause may be found in a malposition of the uterus, in a forgotten pessary, etc. In every case a most determined and thorough search for the cause should be instituted; in only rare instances is such a search unsuccessful.

Certain general principles are applicable in the treatment of the vesical irritation itself from whatever cause. In acute cystitis the patient should keep his bed, be warmly covered, and take an abundance of pure water; flaxseed tea, infusions of uva ursi or of buchu may be administered instead of simple water. The acidity of the urine should be neutralized by the use either of an alkaline mineral water or by the addition of bicarbonate of potassium to the drink; warm milk containing lime-water is a very convenient and efficient drink. The diet should exclude condiments, meat, and alcoholics, and should consist chiefly of milk, fruits, and vegetables.

Locally warm fomentations or poultices may be applied above the symphysis and to the perineum; pressure from the rectum is avoided by securing a fecal evacuation at least once daily. This can be best accomplished by enemata of hot water, which have moveover a decidedly soothing effect. Vesical tenesmus is diminished by suppositories containing opium, but no belladonna. Hot hip-baths, the temperature being maintained at 30° to 33°, should be given at least twice daily, the patient remaining in the bath twenty to thirty minutes. If leeches be employed at all, they should be applied, at the onset of the attack, to the perineum just in front of the anus.

Internally lupulin is much employed; and if there be much suppuration, astringents, particularly tannic and gallic acid, are often administered, though not with very decided effect. It is not always necessary to employ injections in the treatment of acute cystitis; even if there be pronounced ammoniacal fermentation and the formation of slimy masses, the condition of the urine can be much improved by the administration of benzoic acid or the benzoate of ammonium. Five grains of either, given every four hours, usually effect a decided improvement in the condition of the urine. If, however, these measures fail to subdue the inflammation in the course of a few days, there probably exists in the bladder or in its immediate vicinity some constant irritation—a stone, tumor, foreign body, prostatic enlargement, etc.—requiring the introduction of exploratory instruments into the bladder. If this be necessary or if retention of urine requiring the use of the catheter occurs, there remains no longer any objection to local treatment.

Before washing out the bladder, it is extremely important, for reasons already mentioned, to ascertain whether or not this organ habitually contains residual urine. To secure this information the patient is directed

to empty his bladder completely; a clean catheter is then gently introduced; a flow of urine (which should be immediately checked by placing the thumb over the orifice of the catheter) proves the presence of residual urine and the necessity for certain precautions in the treatment. If ammoniacal fermentation has occurred in the bladder (and it is otherwise often unnecessary to resort to topical treatment in acute cystitis), it should be at once arrested, since its products are intensely irritating to the mucous membrane, and recovery is practically impossible until they have been removed. The ammoniacal fermentation can be arrested by various agents, but by none other so quickly and effectually as by the use of corrosive sublimate. This substance—a poison to all organic life—destroys the minute organisms whose vital activity causes the fermentation; one or two ounces of a solution of corrosive sublimate (one part to ten thousand of warm water) should be gently injected after the patient has emptied his bladder; this injection usually causes considerable smarting, and the liquid should be withdrawn at the expiration of two or three minutes. This single act will of itself much diminish the local irritation and vesical tenesmus; but it should usually be followed by a washing out of the bladder, which may be repeated twice daily until the acute symptoms have subsided. In order to wash out the bladder a clean soft catheter is introduced until its eye reaches the prostatic urethra; two or three ounces of a saturated solution of boracic acid (or two drachms of the acid in three ounces each of water and glycerine), heated to a temperature of about 30°, are then gently injected, retained for two or three minutes, and allowed to escape—if necessary by advancing the eye of the catheter to the bladder. In a few minutes two ounces more, at a temperature of say 33°, are injected, held and expelled as before. This injection may be repeated five or six times at one sitting, the temperature of the successive injections being gradually raised to 38°, 40°, or even 42°. There should be no return of the ammoniacal fermentation during the course of the case; if it do recur, it is probably because the instruments used have not been properly cleansed, and a second injection of corrosive sublimate is required.

If the bladder contain residual urine, care should be taken to evacuate only a portion of this urine during the proces of washing. As this is a less frequent factor in the treatment of acute than of chronic cystitis, it will be discussed under the latter head.

In three recent cases I have had gratifying results by keeping hot water in contact with the vesical mucous membrane continuously. After washing out the bladder, the end of the soft catheter (perforated at the extremity instead of at the side) is allowed to rest just within the prostatic urethra; the instrument is connected with a fountain syringe containing a saturated solution of boracic acid, the temperature of which is at first about 38° and is gradually increased by additions of hot water. The reservoir is raised so that the surface of the contained liquid is slightly above the level of the bladder, its height being determined by the sensations of the patient. The vesical mucous membrane is thus continuously bathed in hot water; the urine which enters the bladder is diffused through the liquid; vesical tenesmus is diminished; drainage can be secured at intervals by slightly lowering the reservoir. Tannic acid, hydrastin, morphine, etc., can be dissolved in the water if desired.

The treatment of chronic cystitis varies extremely with the cause, and should not be undertaken until the origin of the affection is discovered. Among the general features applicable to nearly all cases may be mentioned the following:

The improvement of the general health is often a most important item of treatment, even when the vesical inflammation can be traced to some local cause; for a few months' torment from cystitis exercises a most depressing effect upon the patient's general health and strength. The diet, while excluding those articles which render the urine acid and irritating, such as condiments and strong liquors, should be eminently nutritious and may include beer and light wines; it should also be re-enforced by tonics and often by cod-liver oil; derangements of the stomach and intestine must be avoided or corrected. Out-door exercise, even if it require considerable bodily exertion, has exerted a most beneficial influence in certain obstinate cases; Hamilton indeed reports success, after many discouragements, from horseback-riding. The exercise should be at first of short duration and require but little exertion, while both duration aud effort may be gradually increased; women have been particularly benefited by such seemingly violent measures. It is in these obstinate cases of cystitis that the various water-cure resorts have celebrated their most brilliant triumphs; and while the abundant use of a mild alkaline water is certainly most beneficial, it must be admitted that the cures effected by residence at these resorts are attributable to the better hygiene (which is insisted upon at the European baths) and to the fresh air and exercise enjoyed. Residence at the seashore or in the mountains has accomplished the same good result.

Internal medication directed to the bladder avails but little in cases of chronic cystitis. The abundant use of milk and lime-water, re-enforced by some pure alkaline drinking-water in large quantity, probably accomplishes all that can be expected from such medication. The time-honored administration of uva ursi, the balsams, tannic and gallic acids may be tried; the triticum repens, so highly recommended by Sir Henry Thompson, or the chlorate of potassium, introduced by Edlefsen and since recommended by others, may furnish good results. (It is to be remembered that this salt in large doses produces decided irritation of the kidneys.) Turpentine oil occasionally secures a decided reduction in the suppuration and in the vesical irritation; from thirty to fifty drops may be administered in milk daily. Fürbringer and Friedreich assert good results from the internal administration of salicylic acid in large doses—up to two drachms daily—in cases where ammoniacal fermentation was pronounced. These and the innumerable other drugs recommended and employed internally in the treatment of chronic cystitis fail far more frequently than they succeed in producing decided benefit; for they are at best palliative and exert no influence upon the cause of the disease.

If the urine be decidedly acid, a not infrequent condition, the immediate symptoms can be improved by the administration of alkalies and vegetable acids, or by the consumption of small fruits, or by drinking alkaline waters. In these cases there is often a vice of digestion or nutrition, resulting in the increased production of acid. The administration of alkalies, while relieving the bladder from the irritation of the acid urine, exerts no remedial effect upon the cause of the excessive acid production; this is best overcome by measures addressed to the general health, already named. In some few cases it is possible that cystitis is produced by a gouty or rheumatic diathesis; in the absence of all other discoverable causes, such taint, if it exist, should be the subject of treatment.

In nearly all cases local treatment is a most important and essential adjunct; in many instances, indeed, it is the only treatment required, since the cause of the disease is local and anatomical and entirely beyond the reach of internal medication.

The objects and the execution of the local treatment vary with the cause of the affection and with the condition of the bladder as indicated by the urine and by physical examination. Before instituting such treatment it is therefore essential to ascertain whether or not there has existed an impediment to the evacuation of urine; whether the bladder habitually contains residual urine; whether there exists hypertrophy of the bladder, and if so whether or not it is accompanied with dilatation; and whether ammoniacal fermentation of the urine occurs within the bladder.

In many cases an old stricture or prostatic enlargement constitutes the key to the situation, indicating that the cystitis has been caused by the habitual retention of residual urine. Such cases must be handled cautiously, since it is exceedingly probable that there is distention and chronic inflammation of the upper urinary passages; the sudden division of the stricture or the complete evacuation of the bladder through a catheter has been followed by serious results. If there is a previous history of stone, it is quite possible that the same condition—incomplete evacuation of the bladder—exists; it also happens occasionally that after the removal of a stone the bladder remains or becomes incrusted with phosphatic flakes, which keep up a vesical irritation. Enlargement of the so-called middle lobe of the prostate without a general increase in size of the organ, occurs, I believe, far more frequently than the books would lead us to suppose; at any rate it has been my fortune to verify upon the post-mortem table, three times within two months, the existence of such enlargement as the cause of a chronic cystitis. Although it may be difficult or even impossible to recognize such enlargement during life, yet the possibility of its existence should be kept in mind; since a trifling tumor obstructing the vesical orifice of the urethra may produce the same ill effects upon the bladder and kidneys as pronounced enlargement of the entire prostate; and the incautious evacuation of the bladder in such case may have the most serious consequences. In cases of long-standing obstruction to the exit of urine, diverticula frequently exist and should be sought; for their unsuspected presence may render a cystitis extremely obstinate and intractable.

Having ascertained by the history and by physical examination of the patient the probable and possible causes of the cystitis, local treatment may be instituted, accompanied of course, if possible, by the removal of the cause. By daily washing out the bladder, various good effects are obtained in different cases; if the primary difficulty consist in prostatic enlargement or other obstruction, we may hope, by gradually removing the residual urine, not only to remove the exciting cause of the cystitis, but also to accustom the bladder to more complete contraction. If ammoniacal fermentation exist, careful washing of the bladder can be made to remove the irritating products of this action, and to arrest the fermentation; and in every case the cessation of the inflammation may be furthered by astringent applications.

The method employed in washing out the bladder should be carefully chosen according to the requirements of the case. In every instance the least possible mechanical irritation of the inflamed membrane must be secured; hence only soft rubber catheters should be employed, and not more than two or three ounces of liquid should be injected into the bladder at one time before permitting the vesical contents to escape; the use of metallic instruments and the injection of so much fluid as to cause the patient extreme pain, are hurtful in the extreme. The eye of the catheter should rest in the prostatic portion of the urethra, so that the liquid may

wash the neck of the bladder. Double-flow catheters are quite unnecessary and, as commonly employed, injurious; it may be doubted whether by such catheters the general surface of the bladder is reached.

Before the injection, the patient should evacuate the bladder as completely as he can. If upon the introduction of the catheter urine flows, it is evident that the bladder contains some residual urine; and an effort should be made, by examination per rectum and over the symphysis, to estimate the quantity of this retained urine. For it is a vital point to prevent the immediate and complete evacuation of the bladder as has been already often emphasized in these pages. From one to three ounces—the quantity determined largely by the patient's sensations—of water at a temperature of 36° to 40°, are then injected and permitted to remain for two or three minutes; a solution of boracic acid, one part, in water and glycerine, each ten parts, heated to the same temperature, is preferable to simple water. The fluid is then permitted to escape, care being taken that no more liquid leaves the bladder than was injected; the injection is then repeated with the same precautions until the fluid which escapes is quite clear. If there be much pain and irritation the injections may be continued for fifteen or twenty minutes, the temperature of the liquid being gradually raised to 42° or even 45°. After the final injection the quantity of liquid remaining in the bladder may be decreased by a few drachms or an ounce, according to the estimate of the usual amount of residual urine. This operation may be repeated with advantage twice daily. If the urine be of acid reaction, no other injecting fluid than that named need be employed.

As already remarked, the greatest precautions must be taken to insure surgical cleanliness of the catheter employed. Soft instruments should be immersed in a solution of corrosive sublimate, one part to two thousand; and should be lubricated with a mixture of glycerine and water, containing about half this proportion of corrosive sublimate. Great care is necessary not to over-distend the bladder by the injected fluid; hence, so soon as the patient complains of pain from the injection, the liquid should be permitted to escape. In cases of concentric hypertrophy of the bladder in old men, the organ often contains only two or three ounces of fluid when distended to its utmost capacity; in such cases the injection of even an ounce of water causes decided pain, and the powerful expulsion of the same. In this condition of the bladder, benefit is obtained by a very gradual dilatation by means of the injecting fluid, the quantity of which should be slightly increased from day to day. Yet great care is necessary in executing this measure, since, in old men especially, rupture of the bladder can be induced by the exercise of very little force; and even if this disaster be avoided, such distention of the bladder as causes extreme pain undoes all the good which the operation otherwise confers. By introducing the eye of the catheter only to the prostatic urethra, the current of liquid is made to wash the neck of the bladder, which is often the seat of the most violent inflammation.

The washing of the bladder is seldom required more than twice daily, though if necessary to subdue the irritation it may be performed three or four times in the day. As the objects of this measure are to remove the irritating inflammatory products, to arrest fermentation, and (in cases of habitual distention) to accustom the bladder to more complete contraction, its benefits are obtained by using simple water for cleansing the bladder, and some substance such as boracic acid or quinine for arresting fermentation. The employment of astringents, acids, etc., as injections are beneficial only in special cases. If, for example, there is reason to believe,

from the condition of the urine, that the surface of the bladder is incrusted with phosphatic deposits, a dilute solution of nitric or acetic acid may be beneficial in dissolving these phosphates; one or two minims of the dilute nitric acid or four or five of acetic acid to the ounce of water will accomplish all that can be expected. If after fermentation is arrested, there still exist much tenderness and irritation, a daily injection of nitrate of silver solution may exert a good effect. This should be at first not stronger than one grain to eight ounces of water; the quantity may be gradually increased to three or even four grains to the same quantity of fluid. Acetate of lead, tannic acid, etc., are worthless according to my observation. Salicylic or benzoic acid, two to ten grains to the ounce, may be used instead of boracic acid or quinine for arresting fermentation.

If there be decided ammoniacal fermentation in the bladder, this can be at once arrested by a single injection of corrosive sublimate solution (one to five thousand), injected after the bladder has been washed out and and while it contains some liquid. If the sublimate cause much smarting, it should be removed after one or two minutes and replaced by boracic acid and glycerine solution.

Theoretically it is very desirable to secure perfect rest of the bladder; by permitting the urine to escape directly from the ureters without accumulating in the bladder we would not only relieve this organ of the necessity for frequent contractions, but would also prevent the constant irritation of its surface by the contact of the urine. To accomplish these objects, it is often recommended that a soft catheter be tied in the bladder. This measure is, however, as commonly practised, rarely beneficial; for in many cases extreme sensibility of the urethra and bladder-neck render the continuous contact of the instrument unendurable; and the accumulation of urinary ingredients in and around the catheter increases the irritation and the fermentation in the bladder; moreover, in those cases in which the bladder contains residual urine, complete evacuation is extremely undesirable. If it be deemed necessary to tie in the catheter, this should be connected, before introduction into the urethra, by a rubber tube with a basin of boracic acid solution; the liquid is made to fill the catheter, which is then introduced so that the eye just enters the bladder, the rubber tube being meanwhile compressed. A siphon is thus established, whereby perfect draining of the bladder is secured.

In some cases all these measures fail and drainage of the bladder must be effected by other means. In the female this can be readily accomplished by simple dilatation of the urethra, a measure of inestimable value in certain obstinate cases accompanied with extreme sensitiveness of the bladder-neck. In the male, cystotomy has been performed and often followed by perfect recovery; of 47 cases collected by Weir in which this operation was performed for the relief of chronic cystitis, complete recovery or extreme benefit resulted in 23; some relief was afforded in 7 cases, and in 4 no benefit was derived; the remaining 13 died, 3 from the operation itself and 10 from advanced renal disease. In several of these cases the cure resulted not so much from the drainage of the bladder as from the removal of obstructing portions of the prostate. A better operation consists in opening the membranous urethra and inserting a short rubber tube through the orifice thus made into the bladder; the finger should be passed through the wound into the bladder and a careful search for obstructing portions of the prostate made; these if present may sometimes be removed. By this insertion of the finger there is secured a dilatation of the prostatic urethra and neck of the bladder, without which no benefit may ac-

crue from the operation. The most frequent source of failure and disaster in opening the bladder by either one of these methods is the neglect to ascertain in advance the condition of this organ and to recognize the dangers attendant upon the sudden evacuation of residual urine. In those cases in which the bladder is habitually distended and hypertrophied, serious reaction or even a fatal result may be expected from either of the two operations, however skilfully performed.

After opening the bladder, the best results are obtained by placing the patient in a continuous bath of slightly alkaline water, as is the custom of many German surgeons. In this way the inflammatory products are prevented from accumulating upon the vesical mucous membrane, which is, moreover, kept constantly warm and moist. If this plan be impracticable, the patient should at least take several warm hip-baths daily. The experience of Whitehead, Thompson, and other English surgeons during recent years in the digital examination of the bladder will doubtless lead to the more frequent performance of urethrotomy in the membranous portion for the relief of chronic cystitis. In my last two cases of chronic cystitis (both caused by enlargement of the prostate in elderly men) I have employed with great advantage the method of continuous application of hot water to the vesical mucous membrane.

Among the measures employed is counter-irritation above the symphysis ; even the actual cautery has been used for this purpose. It is doubtful whether benefit is derived from anything more severe than the use of a flaxseed poultice liberally sprinkled with mustard or turpentine. Morphine as a subcutaneous injection or in a rectal suppository is often required to relieve pain and tenesmus.

The possibility that a chronic cystitis may be of *tubercular* origin should be remembered, especially in the treatment of scrofulous individuals or those who exhibit evidences of tuberculosis elsewhere. Tuberculosis rarely causes pronounced symptoms in the bladder until it is well developed in other organs of the genito-urinary tract ; nodular enlargements of an epididymis, an asymmetrical and nodular prostate, or a thickened seminal vesicle are usually present to indicate the character of the cystitis. Sometimes, however, all these organs remain apparently normal, while the kidney may be the seat of extensive tubercular change. It is to be remembered that tuberculosis of the genito-urinary tract occurs as a primary affection, and may even lead to a fatal result without causing pulmonary or general disease. This local tuberculosis frequently dates its development from gleet, orchitis, or a simple cystitis ; the affected organs never recover entirely their former condition ; a mild, subacute affection remains, which after months have elapsed first exhibit symptoms that arouse suspicion of the tuberculous nature of the affection. In a few rare instances tubercular cystitis has been developed during the course of a gonorrhœa, both the tubercle bacilli and the gonorrhœal micrococci having been detected in the discharge (Cornil and Babes).

The symptoms of tubercular cystitis are often identical with those of chronic inflammation of the bladder from other causes. They vary in intensity according to the extent of the urinary mucous membrane involved. So far as the bladder itself is concerned, tubercular inflammation is usually limited to the trigonum and its immediate vicinity ; sometimes the kidneys and urethra remain intact, while in other cases the entire urinary mucous membrane from the kidney to the meatus externus, is studded with tubercles and ulcers. As a rule hæmaturia is a prominent symptom in tubercular cystitis ; the quantity of blood may not be large, but it constitutes a

considerable percentage of the sediment. There may be but little pus and epithelium discharged, and the urine remains otherwise normal; occasionally ammoniacal fermentation occurs. In some cases the sediment contains an abundance of cheesy particles, possibly also elastic fibres and minute shreds of mucous membrane. A characteristic of this, as of tubercular inflammation elsewhere, is the improvement which occurs during warm weather and during residence in warm and dry climates. It occurs far more frequently in males than in females; in women tuberculosis of the bladder may be suspected if a chronic cystitis is accompanied by obstinate ulcers at and within the meatus. The presence of a chronic cystitis in females may also possess diagnostic significance in determining the nature of an abdominal enlargement; for a chronic tubercular peritonitis has repeatedly misled experienced surgeons into a diagnosis of ovarian tumor. In one case which came under my observation the patient had, in addition to the abdominal swelling, a chronic cystitis (attributed to pressure by the tumor) and a small but obstinate sharp-edged ulcer just within the urethral orifice. Ovariotomy was determined upon and begun, but the abdominal incision revealed tubercular peritonitis; the left ovary was somewhat enlarged and cheesy. At the autopsy some days later there was found tubercular ulceration of the bladder-neck.

The diagnosis of the specific cause of cystitis is based upon the evidence of tuberculosis in other urinary or genital organs and upon the detection of tubercle bacilli in the urine. The absence of the latter does not necessarily disprove the tuberculous nature of the inflammation; yet their presence, while constituting positive evidence of tuberculosis, does not of itself localize the inflammation in the bladder—in fact, it is often impossible to differentiate between tuberculosis of the kidney and of the bladder; both may be present in the same individual.

The treatment required is in general that employed in chronic cystitis from other causes; there exists of course a special necessity for the use of constitutional measures, including residence in a warm, dry, and equable climate.

Tumors of the Bladder.

Improved methods of diagnosis have shown in recent years that tumors of the bladder are not so rare as most standard works lead us to infer. Up to the present time the literature of the subject is scanty and inaccurate; but there is reason to believe that the increased certainty of diagnosis and hopefulness of treatment afforded by surgical interference will reveal their more frequent existence and lead to a more accurate classification than is possible with the data now at command.

Tumors of the following varieties have been found in the bladder:

Polyps—Papillomata (villous growths);
Myxomata;
Fibromata;
Myomata;
Carcinomata—Epithelioma;
Encephaloid;
Scirrhus;
Sarcomata;
Dermoid Tumor.

In quite a number of vesical as of other tumors, the characteristics of different growths are found combined—fibro-sarcoma, etc.

The benignant tumors—the fibrous, mucous, and villous polyps—constitute the greater number of vesical neoplasms. In some cases they are found post-mortem where no symptoms had revealed their existence during life. Their presence is indicated either by mechanical obstruction to the exit of urine, by their appearance at the meatus (in the female), or by hæmaturia, a feature especially common to the villous polyps. They may be found at any time of life (the mucous polyps have been found in children only) and occur with about equal frequency in both sexes.

The villous polyps are sometimes short and sessile, but usually consist of several long, papillary projections floating loosely in the urine and flattening out when the bladder is opened; these should be examined in water. Each of the projections consists of a capillary loop covered with a layer of epithelium. The myxomata or mucous polyps are soft, smooth, and often pedicled, like the soft polyps of the nose. The fibrous polyps are of firmer structure and often of larger size.

Polyps are usually single, but occasionally several growths are found in different parts of the bladder. In size they vary from that of a pea to such dimensions as to entirely fill the bladder; in shape, too, they vary, being sometimes flat and scarcely elevated above the surface, while in other instances they constitute large solid or branching masses attached by a single slender pedicle. In one respect they are alike: the polyps as well as the malignant growths usually spring from the trigonum and its immediate vicinity.

Myomata of the bladder are extremely rare; only three cases of pure myoma and three or four of mixed myoma have been recorded. Yet these have been so situated and have attained such dimensions as to cause serious difficulty. Billroth removed a myosarcoma as large as the fist from a boy twelve years of age, by suprapubic cystotomy. Volkmann attempted the same operation upon a man fifty-four years of age who had for several months suffered from frequent and painful micturition and vesical hemorrhage. The tumor was about three and a half inches long and two and a half thick; it was a pure myoma.

The villous growths of the bladder are quite frequent; and there has been much discussion as to their malignancy. It is, however, now established that two different classes of neoplasms have been designated by this common name, since each may grow as a collection of branching, tree-like masses. The more delicate of these—those in which the capillary loops are covered by a single layer of epithelium—are not malignant, and have been classed with the polyps. The other variety is of a firmer structure, deeply rooted in the submucous connective tissue; its capillary loops are covered by several layers of epithelial cells, frequently atypical; this is properly an epithelial cancer. Occasionally tumors of other origin take the form of a villous growth.

Cancer of the bladder is either primary (rare) or secondary. It is far more frequent in females than in males, because of the frequency of cancer in the adjacent uterus. In 11,811 autopsies made in the Berlin Pathological Institute between 1859 and 1880, only 77 cases of vesical cancer were observed—less than one per cent.; of these 77 cases, 65 (eighty-four per cent.) occurred in females and only 12 (sixteen per cent.) in males. In Dresden 73 cases of vesical cancer were found in 2,505 autopsies (2.9 per cent.) In nearly all cases cancer of the bladder is secondary to carcinoma of adjacent organs—in women of the uterus, and in men of the prostate or rectum; in a few cases cancer occurs in the bladder by metastasis from distant organs. In females it is found most frequently between the ages

of thirty and forty-five years; in males it is usually a disease of old age; yet it has been observed in children, Smyth reporting a case of encephaloid in a girl four years old. Carcinoma of the bladder sometimes appears as a diffuse infiltration of the vesical wall; more frequently it grows from a definite point, usually in or near the trigonum, sometimes on the posterior wall. As to the relative frequency of the different forms of cancer in the bladder, opinions are conflicting; that villous growths and epithelial cancers are the most frequent, appears to be generally admitted; scirrhus is according to Thompson nearly as frequent as these, while encephaloid is very rare; most collators reverse the relative frequency of these two varieties.

The existence of primary cancer of the bladder has been denied; yet it does undoubtedly occur, though far less frequently than as a secondary growth. Primary cancers of the bladder are usually epithelial or villous; Stein, in his admirable monograph on "Tumors of the Bladder," collects at least sixteen cases in which "the primary origin of the cancer in the bladder cannot be doubted, though I have been circumspect in my selection of them." Ten of these cases were males and six females.

Sarcomata of the bladder are generally considered rare, only nine cases having been reported under that name; it is, however, probable that various tumors recorded as encephaloid cancers really belong in this class of neoplasms.

The various malignant tumors of the bladder undergo ulceration, particles of the growth being frequently expelled with the urine; indeed, the size of the tumor may in time be much decreased in this way. Cystitis is usually excited, and the surface of the growth covered with phosphatic deposits. In a few rare cases calcareous transformation of vesical tumors has occurred, misleading surgeons into the diagnosis of calculus.

Symptoms.—Three symptoms—irritability of the bladder, hæmaturia, and pain—are regularly associated with vesical tumors of all varieties, sooner or later in the course of the affection. Malignant growths and many benignant forms which cause persistent obstruction to the exit of urine, are accompanied by another and most important symptom—emaciation and cachexia.

Irritability of the bladder is usually the first symptom and one which remains for a long time inexplicable, leading to a diagnosis of vesical or uterine neuroses, etc. This may be the only symptom exhibited for months; if the frequency and uneasiness during micturition gradually increase without apparent cause, a suspicion of vesical tumor should be entertained. This vesical irritability, while often the earliest, is by no means a constant symptom; in the benignant and even in some malignant growths it is occasionally lacking. The intensity of this symptom depends partly upon the size, but largely upon the location of the tumor; when located at or near the urethral orifice, even a small tumor may occasion pronounced dysuria, while a growth situated at the vertex of the organ causes comparatively little disturbance.

It is worthy of note that those cases in which frequent and painful urination have long preceded the appearance of hæmaturia, have usually proved to be malignant growths; while those in which hæmaturia precedes the vesical irritability are usually benignant (frequently villous polyps).

Hæmaturia is the most constant symptom of vesical tumors, and the one which often renders the other symptoms intelligible by directing suspicion to the actual condition. The amount of blood lost and the constancy of its flow vary with the nature of the growth; villous polyps

bleed early and often, if not continuously, a fact explained by the structure of the mass, which consists of blood-vessels covered with a little epithelium. Hæmaturia is frequently the first as well as the most prominent symptom of these growths; in a few instances it is the only one observed. In malignant growths, hemorrhage is a later symptom, usually occurring only after irritability of the bladder and even cachexia are established symptoms; the reason for this lies evidently in the fact that these tissues bleed only after ulceration has occurred. In some few cases of cancer, sarcoma, myosarcoma, and fibroma, hæmaturia was at no time observed. In Billroth's case the tumor (myosarcoma) was as large as a small fist; in Marchand's (sarcoma) it was as large as an apple; in Gibbon's and in Rankin's (encephaloid) as quoted by Stein, the tumors were as large as two fists and a child's head respectively; yet in none of these was hæmaturia observed at any time.

At first the blood is often noticed only at the close of urination, when the growth undergoes pressure by the contracting bladder. The urine first passed may be quite clear, while the last drops consist entirely of blood. The hæmaturia from vesical tumor may be intermittent, appearing for a day or a week, and then disappearing for a variable interval; by close questioning we may often elicit such a history from a patient who had almost forgotten the symptom, which at the time was quite alarming. Another characteristic feature of the hæmaturia is its occurrence without appreciable cause; hemorrhage caused by a calculus is provoked and increased by bodily exercise and subdued by rest, while that proceeding from a neoplasm may appear during bodily repose, even at night. The urine is clear on one day and bloody on the next, even though no unusual exertion has been made. It is worthy of note, however, that vesical tumors, so soon as they are accompanied by cystitis or hæmaturia, frequently lead to the formation of a calculus; so that the characteristic symptoms of the two may be combined.

Pain is an almost constant symptom in malignant cases, though a few instances are on record in which but little or no suffering was experienced. Benignant growths are not of themselves productive of pain; but by obstructing the vesical orifice or by the formation of blood-clots, they may cause painful straining at urination.

The pain of a malignant neoplasm, felt at first above the symphysis and in the perineum, soon radiates down the thighs and up the groin. It often becomes agonizing, particularly in the thigh, presumably from pressure of the growth upon nervous trunks. An excess of pain in one thigh and groin indicates the presence of the growth upon the same side of the bladder. Sometimes pain is felt in the rectum, and defecation may cause much suffering. The pain may extend to the region of the kidney, either by sympathy or from the development of hydronephrosis in consequence of the obstruction of the ureter by the neoplasm.

Emaciation and cachexia are almost invariable accompaniments of malignant disease of the bladder as elsewhere; while benignant tumors usually produce no such effect. If, however, the tumor be so located as to seriously interfere with the evacuation of the bladder, if it bleed freely and constantly, the patient may suffer a decided loss of flesh and strength.

Diagnosis.—At an early stage the diagnosis is generally difficult. Irritability of the bladder is often an early, and for a long time the sole symptom; in the absence of obvious cause, this symptom should lead to a manual examination and a suspicion of vesical tumor.

The appearance of hæmaturia and of pain in the region of the bladder

is generally recognized as a suggestion of a tumor. At this stage the symptoms are often identical with those of vesical calculus, and a differential diagnosis between the two must be made; yet vesical irritability, hæmaturia, and pain may be produced by other conditions—prostatic enlargement, concentric hypertrophy of the bladder with retention of urine, pyelitis and nephritis, and even stricture; these conditions must therefore be excluded as a preliminary to final diagnosis.

Vesical calculus causes symptoms which are aggravated by bodily exercise, riding over rough roads, etc., but are much improved by perfect repose; the hæmaturia, pain, and vesical irritability produced by a tumor in the bladder, on the other hand, are to a great extent independent of the patient's movements. Vesical calculus, while causing frequent micturition during the day, often permits a comparatively uninterrupted night's rest; while a vesical tumor arouses the patient by night as well as by day. A symptom which is regarded as characteristic of calculus—sudden stoppage of the stream during urination—is also sometimes exhibited by pedicled tumors of the bladder, which may suddenly and temporarily occlude the urethral orifice. Calculi early induce a pronounced cystitis, often with ammoniacal fermentation; while tumors may exist for a long time, even throughout their course, without producing any decided vesical inflammation; this is especially true of the benignant growths.

The passage of fragments of tissue with the urine may furnish the means for a definite diagnosis as to the existence and even the nature of a vesical tumor. Yet the observer must wait for fragments of such size as to indicate the structure of the growth, and should beware of basing an opinion upon individual cells, however enticing and atypical these may be; for a simple cystitis may furnish atypical cells, and the ulceration produced by a calculus may cause the appearance of fibres and minute fragments of tissue with the urine.

A physical examination affords valuable evidence in determining the nature of the case. The sound may readily detect a calculus; yet it is to be remembered, first, that calculus often coexists with a tumor, and, second, that a neoplasm may become so incrusted with urinary salts as to give an audible click when struck by the sound. A movable tumor thus incrusted could hardly be distinguished from a stone by the sound alone; but by means of a small lithotrite a fragment may be broken off and withdrawn for direct examination, a procedure which occasions some bleeding if the mass be a neoplasm.

If a vesical tumor only be present, the information furnished by the sound may be much or little. A small, soft growth, or even a large villous tumor, may furnish absolutely no evidence of its existence to the sound, except possibly a feeling of slightly greater resistance than is offered by the urine. A mass of firmer consistence, located as it usually is near the urethral orifice of the bladder, while affording no distinct outline, furnishes nevertheless a most important sign; it limits the rotation of the sound on one or the other side. In a case of epithelioma of the bladder in an old man under my care, this obstruction to the rotation of the sound was the only physical sign furnished by the bladder; a most thorough examination made under an anæsthetic failed to reveal to either sound or hand any other evidence of a neoplasm. The touch of the sound usually causes extreme pain at some particular point, and it may be even possible to detect an unevenness of the surface. Rectal examination, assisted by the pressure of the hand over the symphysis, sometimes detects a decided hardness and thickening of the bladder-wall just above or to one

side of the prostate; occasionally a rough, nodular mass can be recognized. With the sound in the bladder and the finger in the rectum or the hand above the symphysis, these characteristics may be more plainly revealed.

In some cases the introduction of a catheter into the bladder has been the means of removing fragments of the growth; Ultzmann thus detached a piece of a villous growth an inch and a half long, constituting apparently the greater part of the tumor, since the patient was thereby immediately and permanently relieved from the hæmaturia and dysuria which had long tormented him. A catheter should be introduced and the bladder washed out with warm water; if no fragments are thus obtained, the evacuating apparatus employed in lithotrity may be used (Thompson).

FIG. 20.—Fragment of Vesical Papilloma (Villous Growth). (Ultzmann.)

Progressive emaciation affords a strong presumption of the existence of a malignant vesical tumor, especially if the absence of calculus can be determined. In some of these cases decided enlargement of the inguinal and pelvic glands can be detected.

After it has been established that a vesical tumor exists, it is highly important, both for prognosis and treatment, that its degree of malignancy be determined. The villous polyps afford the most characteristic symptoms; from them hemorrhage is early, frequent, and profuse; the villous cancers also furnish considerable blood, though usually much less than the benignant papillomata. During the intermissions of hæmaturia, the patient is often quite free from pain and discomfort, symptoms which seem to be produced merely by the formation of blood-clots and consequent vesical irritation. Benignant tumors cause little local and general disturbance; there is frequently no cystitis and but little vesical irritation. Malignant tumors, on the other hand, often produce dysuria and pain long

before hæmaturia is observed; and a violent cystitis is a usual feature. The pain is constant and far greater than can be accounted for by the disturbance of the vesical functions.

Ultzmann has called attention to a feature of the urine characteristic of villous growths. Even when the urine contains but little blood, and is at the time of evacuation quite thin and watery, it soon coagulates into a viscid mass which does not flow from the vessel; this coagulation may occur in a few seconds.

The passage of fragments of the tumor sometimes reveals its nature. This most frequently occurs in cases of villous growths (Fig. 20); in other instances it may not happen until ulceration has occurred. It is usually

FIG. 21.—Necrotic Fragment of Vesical Tumor containing numerous Crystals of Hematoidin (Ultzmann).

accompanied with considerable hemorrhage, though cases are recorded in which large pieces have been expelled without coincident hæmaturia. Although care is necessary in drawing deductions from the presence of such fragments, it is certain that the value of the microscopic examination of these pieces has been much underestimated. So-called "cancer-cells" exist only in the imagination of enthusiastic microscopists; individual cells rarely if ever warrant a diagnosis as to the nature or even the presence of a vesical tumor, but aggregations of cells frequently afford positive means for diagnosis. In view of Sir Henry Thompson's well-known conservatism and of his general distrust of the microscope, it is gratifying to read his most recent utterance: "In cases of villous and papillomatous

and indeed of all tumors the microscope is of great value. After my recent experiences, I attach much greater importance to it than I formerly did."[1]

The fragments passed sometimes, especially in the early stage of the disease, exhibit well-preserved anatomical elements. In other cases, especially those in which ulceration has occurred, the particles may present even under the microscope nothing which can be recognized as tissue. For the mass is often necrotic; in this condition it may readily be mistaken for the product of a diphtheritic cystitis. Sometimes the mass is characterized by the presence of numerous hæmatoidin crystals (Fig. 21), while in other instances microscopic, colorless, spherical rosettes, probably consisting of calcium oxalate, are discovered (Ultzmann). Such fragments can be found by a careful search in the sediment, facilitated by pouring this into a shallow vessel of water; sometimes little masses which apparently consist merely of urinary salts are found to be fragments of tissue incrusted with phosphates, etc. The failure to discover particles which can be recognized as fragments of a morbid growth does not argue against the existence of such neoplasm; for in certain carefully observed cases no fragments have been discovered; and on post-mortem examination the growth is often found intact, showing that no portions of it have escaped.

In females the diagnosis is sometimes much facilitated by the appearance of the growth at the meatus; in various instances a neoplasm of the bladder has been thus forced upon the attention before the symptoms had aroused a suspicion of its existence. The passage of fragments is also more frequent.

In many cases the information afforded by the means already mentioned is quite unsatisfactory, leaving the nature and even the very existence of a suspected tumor in doubt. Until recently it was customary to await developments, as surgical interference was considered inadmissible; at a later date, especially after Simon's experience, the dilatation of the urethra in the female became a recognized procedure in the diagnosis and treatment of vesical tumors. It is certainly a most valuable measure and devoid of danger when properly performed; by the introduction of the forefinger into the urethra and the middle finger of the same hand into the vagina, while pressure is made with the other hand above the symphysis, a large part or even the entire mucous membrane is brought within the reach of the finger.

Digital exploration of the bladder in the male had been occasionally made, as an incident in cystotomy and lithotomy, for many years; but recently several English surgeons, notably Whitehead and Thompson, have practised and advocated external urethrotomy of the membranous urethra as a means for the digital exploration of the bladder in cases of suspected tumor. The operation is in itself devoid of danger, and may be performed in those cases in which other means fail to establish a satisfactory diagnosis. Whitehead relates 8 recent cases in which the bladder was explored by this method in cases of suspected tumor; in 4 a tumor was found and removed; in 4 others no growth was discovered, but the symptoms were relieved by the operation. Sir Henry Thompson has made the exploratory operation in 42 cases altogether; in 18 a vesical tumor was found and in 16 the growth was wholly or partly removed; in 2 he considered the attempt unadvisable. In 2 cases he was led into operating by the appearance in the urine of "large, soft-looking fibres with nuclei on them, as if developed from cells and significant of growth of some

[1] Med.-Chir. Trans., 1883, p. 350.

kind;" these were associated with the symptoms and history of the tumor. In these two cases, however, no neoplasm was found, yet the patients were much benefited by the operation. Thompson further states as the result of a careful examination of the vesical tumors preserved in the London museums, that about sixty per cent. seemed to be benignant growths, over half of which were removable by operation; he now regards these affections as more frequent than has been usually supposed. At any rate the safety and value of the exploratory operation through the membranous urethra is established.[1]

Course and Duration.—These vary extremely according to the location and character of the growth. The benignant tumors are not incompatible with many years of life and comparative comfort; yet they sometimes induce a fatal result within a few years or even months; this effect is produced even by polyps, by mechanical obstruction at the orifices of the ureters or of the urethra, whereby distention of the renal pelves, hydronephrosis, and perhaps dilatation of the bladder, with their attendant ills, are produced. The frequent and excessive hemorrhage from villous growths may seriously impair the patient's strength; moreover the constant irritation, frequent urination, and pain in the perineum, whereby the patient is prevented from sitting with comfort—symptoms which are most prominent when the tumor grows from the trigonum—contribute materially in exhausting the individual. The chronic cystitis so frequently induced and so intractable is another factor in producing the same results. Death occurs either from exhaustion or from uræmia, the latter produced by the occlusion of the urinary passages or by the supervention of renal disease.

Dubious as is the prognosis in cases of benignant vesical tumors—without surgical interference—the outlook is still less hopeful if the growth exhibit a malignant character; for in this case the patient contends with all the difficulties induced by other tumors—except, perhaps, that the loss of blood is less—and in addition is exposed to the inroads of the growth upon neighboring organs. Moreover, an intense and exhausting vesical catarrh is almost inevitable.

Yet notwithstanding these unfavorable features, actual and possible, the subject of vesical tumor often lives for many years and dies of an independent affection. While it is usually stated that the average duration of malignant tumors is not more than one or two years, instances are known in which such disease appears to have existed for five, eight, and even nine years; and Stein observed a case of encephaloid cancer of the bladder, which he is sure must have existed for seventeen years. There is of course an element of uncertainty in fixing the commencement of the affection; and it is quite possible that a malignant growth is subsequently implanted upon a neoplasm which was for a time benignant.

As to the duration of the non-malignant tumors, there exist no data sufficient for a conclusion. In some cases spontaneous expulsion of the growth and subsequent recovery has occurred; in others hæmaturia and other symptoms of vesical tumor have been observed intermittently for eight, sixteen, and even twenty years.

Treatment.—This has generally been limited to attempts at palliation; and in the treatment of malignant tumor there is certainly no hope of ef-

[1] Of the 18 neoplasms constituting the series, 8 are described as papillomata (chiefly villous growths), 4 as fibro-papillomata, 2 as epitheliomata, 2 as intermediate or transitional, and 2 as uncertain, probably malignant. Of the 18 patients 7 were entirely relieved, 3 improved, 4 recovered from the operation without marked improvement, and 4 died within a few days.

fecting a radical cure. The symptoms which call for treatment are pain, vesical irritability, hemorrhage, and secondary cystitis. By the free administration of anodynes, and by avoiding physical exertion, much can be done toward securing comfort of both mind and body; by securing regular evacuation of the bowels, local discomfort is decreased. For checking hemorrhage ergot, sulphuric acid, gallic acid, iron, and turpentine, in large doses, may exert some effect, though they are not to be relied upon; better results are to be obtained by applying ice to the hypogastrium and perineum, or by introducing it into the rectum or vagina. Sometimes astringent injections into the bladder are required; tannic acid, alum, and a solution of silver-nitrate (five to thirty grains to the ounce) may be used. In making the injection care should be taken to introduce the eye of the catheter only to the prostatic urethra, so as to avoid contact with the tumor whereby hemorrhage would be promoted. It is noteworthy that while the urethra is very sensitive and reacts strongly upon the contact of irritating liquids, the bladder is far less vulnerable; the undiluted solution of the persulphate of iron has been repeatedly injected into the bladder to arrest hemorrhage, without producing ill effects. In these cases, however, the injection has been made through a perineal incision, thus avoiding the urethra; so powerful an irritant could scarcely be introduced with safety through the urethra. The cystitis, which constitutes a most prominent and painful feature in cases of malignant vesical tumor, should be treated according to the principles already discussed.

The supervision of a case of vesical cancer is an extremely thankless and painful duty; there should be no hesitation in administering morphine as frequently as is required to at least mitigate the intensity of the pain. It has been a mooted question whether or not surgical interference is justifiable in such cases; if the patient's strength permit, cystotomy or perineal urethrotomy should certainly be performed, for the relief from pain and from the tormenting frequency of urination, which alone suffices to render existence wretched, would be of itself ample compensation. But the surgeon gains in addition the opportunity for direct treatment of the vesical mucous membrane, whereby inflammation and hemorrhage can be more efficiently controlled. Moreover, although a radical removal of the growth is not to be expected, it has been demonstrated repeatedly that by tearing and scraping away portions of the growth, the patient's condition is much improved. Hemorrhage need rarely be feared; first, because the danger of its occurrence is not great, and, second, because a direct injection of persulphate of iron or other powerful styptic can be made directly to the bleeding surface.

The removal of vesical tumors in females through the dilated urethra has been a recognized surgical procedure since the publication of Simon's successes; in his monograph published in 1881 Stein collects 23 such cases. In 17 of these the removal was accomplished by dilatation of the urethra, in 6 by incision of the urethra or of the vesico-vaginal septum, the age of the patients varying from twenty-two months to seventy years. "The growths removed included papillomata, myxomata, myomata, and sarcomata. The tumors have been removed by simple torsion and avulsion, by ligature, silk and catgut, silver wire, by écraseur and by scooping out with a sharp spoon. Excepting the method of scooping, in which the hemorrhage is sometimes considerable, the loss of blood in the other operations was insignificant." Of the 23, 13 recovered, 2 were improved, and 8 died; in only 1 of the 8 was the operation the cause of death—a case in which perforation of the bladder and peritonitis ensued from the attempt

to remove a sarcoma. In one of the successful cases, Simon "scooped out from the walls of the bladder a sessile tumor that had occupied two-thirds of the cavity of that viscus."

The attempt to remove a tumor from the male bladder had been made less frequently; Stein collects only 11 such operations. Six were entirely successful, while in 5 death occurred; in 3 of these 5 the fatal result was attributable to the operation.

Since this publication of Stein's surgical experience in the removal of tumors from the male bladder has been materially extended. As already stated, the digital exploration of the bladder by perineal incision has been quite frequently made in the last three years; and while no tumor has been found in several cases where the symptoms indicated their presence, yet even in these cases improvement has resulted. In twenty-two instances a tumor was found and in twenty successfully removed; even a partial removal has been found to exert a most beneficial effect (Thompson). When it is remembered that the treatment of vesical tumors without surgical interference is at best palliative; and that the tendency of such tumors, benignant as well as malignant, is to a fatal termination, it is evident that the operation in question is justifiable and highly promising. Thompson asserts even more in favor of the operation; he says: "Unless removed by surgical operation, vesical tumor is inevitably fatal. Every recovery is a clear gain; and a fatal issue is simply the natural termination forestalled." Objection may certainly be raised to the first and therefore to the concluding clause of the second statement. For in some cases spontaneous expulsion of the tumor and recovery have occurred; while in others (of benignant growths) the condition has existed for years without seriously impairing the patient's health, his life being finally terminated by some independent disease. Yet there can be no question that in serious cases, where a fatal termination may be expected, the operation should be performed; and the earlier it is done, the better are the chances for immediate recovery and permanent cure.

That a complete removal of a benign growth often insures permanent relief is evident from the history of cases already on record; and it is possible that the removal of the greater part of a tumor is sufficient to produce the same result. Thompson says: "I am satisfied that with non-malignant products, a complete ablation of the growth is not absolutely essential to success. I am quite certain that I have removed the greater part, but not the whole of the tumor in two cases at least, in which there has been no sign of reappearance for upward of a year. I have had in one case the unusual advantage of being able to place my finger on the very site of an evulsion performed nine months before, and I then found no reappearance of growth so far as my sense of touch enabled me to judge."

Neuroses of the Bladder.

By this name are designated various derangements of function of the bladder, unaccompanied by any constant lesion of this organ. In some cases they are undoubtedly caused by morbid conditions of the bladder itself or of other urinary organs; while in many instances it seems impossible to assign any more definite cause than a nervous, often psychical influence.

Spasm of the Bladder.

Spasmodic contraction of the vesical muscles is usually accompanied with pain; when this feature is very prominent the condition is termed "neuralgia" of the bladder. In only rare cases of vesical neuralgia is there an utter absence of spasmodic contraction, which may be manifested by either sphincter or detrusor muscles. The former condition is witnessed in the lightest grade by certain nervous individuals who are unable to void urine in the presence of a second person; indeed, some patients complain that they experience difficulty in performing the act except under certain special circumstances. Thus occasionally a person is found who can empty the bladder only when he assumes the sitting posture and enjoys entire solitude; Ultzmann observed an individual in whom this spasm was so marked that urination was rendered possible only by the use of a large injection of morphine.

In general, spasmodic contraction of the vesical sphincter is indicated by an inability to expel the urine in immediate obedience to the will; such patients are usually compelled to wait several (even five or ten) minutes before the bladder obeys the volition. Only after vigorous voluntary contraction of the abnormal muscles does the urine appear; and even then the stream is small, often interrupted, sometimes consisting of drops; a dribbling at the close of the act is frequent. The patient often experiences the feeling that he has not completely emptied the bladder, and he may be even compelled to desist from the effort without having expelled any urine. Such individuals are usually tormented by a frequent desire to urinate, and in many cases there is a more or less constant dull, heavy pain behind the symphysis.

Spasm of the detrusor causes an almost constant desire to urinate; the collection of the smallest quantity of urine in the bladder causes the patient a constantly increasing uneasiness, which is relieved—and then only partially—by vesical contraction. Pain is often lacking in this condition. In the most pronounced cases the evacuation of the urine is almost constant, so that the patient suffers from persistent enuresis during the day, though often relieved at night. Sometimes the desire to urinate is so imperative that the patient is unable to make the necessary preparation, the urine escaping into the clothing. This condition, like spasm of the sphincter, may be transient, lasting only a few hours or days; but it is prone to recur.

In perhaps the majority of cases of vesical spasm, both sphincter and detrusor are affected. In these cases there is pronounced "irritability of the bladder;" the patient is tormented by constant desire to urinate, which is, however, gratified only by strong voluntary muscular contractions, and often only after a delay of several minutes. There is decided pain, constant or intermittent, in the vicinity of the bladder-neck. Many patients are further annoyed by frequent dribbling of urine and by sudden and involuntary expulsion of the vesical contents into the clothing.

Spasm of the bladder is doubtless always a symptom of some morbid condition, though it must be admitted that in some instances the attempt to trace it to a given cause has failed; in every case a most careful examination should be made in the hope of detecting the cause. It will sometimes be found, especially in children, that there exists a constant irritation of some adjacent organ; constipation, worms, fissures, ulcers of the rectum, phimosis, the accumulation of smegma under the prepuce, a contracted

meatus, a displacement or inflammation of the uterus, are all capable of inducing this condition of the bladder. In adult males the cause of the trouble is usually found in hyperæsthesia or inflammation of the prostatic urethra, produced by gonorrhœa, venereal excesses, masturbation, or sexual excitement without gratification (toying with females). Vesical irritability or neuralgia in males is brought to the notice of the physician most frequently as an incident to nocturnal pollutions, spermatorrhœa, partial impotence, and chronic prostatitis. It is produced by continence only when this follows habitual sexual indulgence or when the individual is addicted to erotic fancies and lewd thoughts. In short, the existence of this symptom should lead to a full investigation of the patient's sexual condition.

Prostatic congestion can be maintained without sexual disorders, by enlargement of the gland, by habitual portal congestion, and by constipation ; hence vesical irritability is seen in men addicted to the pleasures of the table and in the subjects of prostatic hypertrophy ; of this latter condition it is an early symptom.

The presence of foreign bodies or of neoplasms in the bladder may be the unsuspected cause of vesical spasm. It is to be remembered that an early and for a long time the sole symptom of malignant vesical tumor may be irritability and spasmodic contraction of the bladder. The condition of the urine may explain an obscure vesical spasm ; for this derangement of function is exhibited not infrequently in the course of diabetes, and is sometimes an early symptom of chronic nephritis and pyelitis. Even simple excessive acidity of the urine is sometimes responsible for the vesical spasm, which is immediately relieved by the abundant ingestion of water, with or without alkalies. In some of these cases there is found a persistent alkalinity of the freshly voided urine, and a copious precipitate of phosphates. This condition—sometimes miscalled phosphaturia—is usually associated with some disorder of the central nervous system, especially those originating in sexual abuses ; by administering benzoic acid the reaction of the urine can be rendered neutral or acid, but the vesical irritability is not thereby relieved.

In still other cases the spasmodic action of the vesical muscles appears to be one manifestation of hysteria, hypochrondriasis, or emotional tension, and occurs especially in anæmic and chlorotic subjects. It is found also in malarial, rheumatic, and gouty patients, and relieved by measures addressed to these taints. It is occasionally a feature of physical or mental exhaustion.

In some instances vesical spasm is induced by the presence of a urethral stricture ; and if the ordinary sound fails to detect one, the bulbous sounds or the urethrometer of Otis or Weir should be employed. There can be no question in the mind of one who has investigated, that a "stricture of large calibre," unrecognizable without splitting the meatus or employing the urethrometer, is capable of inducing the condition under discussion, and that the removal of such stricture by urethrotomy causes immediate and complete relief.

The *course* of this affection is quite variable. In some individuals an attack lasts only a few minutes and recurs at intervals of many days or weeks, causing therefore no interference with the performance of their duties ; while in others attacks are frequent and prolonged, keeping the individual in constant misery and rendering him unfit for the pursuit of his avocation. Sometimes spontaneous recovery occurs, while in other instances all attempts at relief are only palliative. In these persistent cases the frequent muscular contractions finally produce hypertrophy (concentric) of the bladder and chronic cystitis.

Diagnosis.—Vesical spasm, irritability, and neuralgia are evident symptoms; the problem in diagnosis is to determine the cause. They are produced by calculi and tumors in the bladder as well as by the conditions already mentioned; hence an examination with the sound is necessary. Even if nothing abnormal be discovered in the bladder, the sound will probably reveal an exquisitely sensitive prostate—the usual source of the trouble. If the passage of the instrument through the prostatic urethra occasion much pain while the contact of its point with the vesical wall cause no additional complaint, and if the urine be free from pus, calculus and cystitis may be excluded and the symptoms attributed to prostatic hyperæsthesia. Yet since other factors contributing to the difficulty may also exist, a careful examination of genitals, perineum, anus, urine, and general condition should not be omitted.

The *treatment* is indicated by the assumed cause. Sometimes it consists entirely of measures directed to the improvement of the general health; sometimes it requires an entire change of habit, occupation, and even residence; in all those cases in which a morbid condition of the prostatic urethra is detected, the local treatment is extremely important. The gentle and regular introduction of steel sounds, which are permitted to remain ten or fifteen minutes at a time, contributes materially to overcoming a spasm of the sphincter; the use of Winternitz' cooling sound, whereby a stream of cold water can be made to circulate through the instrument as it rests in the prostatic urethra, is a valuable adjunct in those cases in which there is hyperæsthesia of the prostate. In one obstinate case which had resisted many attempts at relief, I effected a complete cure by dividing the meatus and introducing a No. 22 English into the bladder, permitting it to remain for ten minutes; doubtless this result was largely due to the stretching of the sphincter (the membranous urethra). In some few cases the application of a strong solution of silver-nitrate or even of the solid stick to the prostatic urethra is said to have given relief; in these cases there is perhaps, as Ultzmann suggests, a fissure or erosion at the neck of the bladder. In all instrumental manipulations in cases of suspected vesical spasm, the greatest care and skill should be employed; for if upon failure to enter the membranous urethra the point of the instrument be moved to and fro, the sphincter is irritated to firmer contraction and resistance. Small doses of the bromide and iodide of sodium or potassium, four or five times daily, may be combined with the local treatment; undue acidity, alkalinity, concentration or dilution of the urine should be corrected. If pain—"neuralgia of the bladder"—be the most prominent symptom, chronic prostatitis probably exists, indicated by the appearance of threads of pus in the urine without a constant gleety discharge.

In women, in whom vesical spasm is more frequent than in men, dilatation of the urethra is a most effective measure, which often relieves cases otherwise intractable. The dilatation of the membranous urethra in the male by the use of large sounds—up to 18 or 20 English—offers the same hope of success, and should be employed after other measures have failed. For vesical irritability in women, independent of uterine difficulties, Bartholow recommends cantharides.

Occasionally the physician is called upon to give the patient relief from the intense pain and irritation of a violent spasm. The sufferer should be placed in a warm bath or hip-bath of 33° to 35°, and a hypodermic injection of morphine administered. After the bath, which may last twenty or thirty minutes if relief be not sooner obtained, full doses of the bromides should be given for a day or two. The physician should not be misled in

a false diagnosis by the intensity of the symptoms in an attack of this sort; for violent spasm of the bladder with its accompanying pain may produce pallor, a rapid and frequent pulse, mental distress and anxiety, general bodily tremor, and, in women and children, even convulsions and syncope.

Paresis of the Bladder.

Inability of the bladder to evacuate itself completely and promptly—a condition to which the term atony or paresis is applied—is usually, like spasm of the same muscles, a symptom; it is, for example, a regular and inevitable result of a mechanical impediment to the evacuation of urine, though compensatory hypertrophy commonly occurs; it is a symptom of several diseases of the brain and spinal cord, and has been observed, in connection with hysteria and diabetes, during convalescence from many acute diseases, especially those accompanied with a high temperature. It seems also to result occasionally from over-stimulation of the adjacent genital apparatus, having been observed in persons addicted to sexual excesses and onanism; in such cases it is probably caused by habitual spasmodic contraction of the sphincter.

In a large percentage of the cases paresis of the bladder results from the habitual voluntary retention of urine for an undue length of time. Those who are engaged in sedentary pursuits or other employments which lead them to neglect or to repress the inclination to evacuate the bladder are especially often sufferers from this complaint. The result of this neglect, frequently repeated, is a gradual stretching and loss of power of the detrusor muscles. Even a single retention for many hours, induced voluntarily from a lack of opportunity to urinate, produces a marked effect upon a previously healthy bladder; for when the attempt is finally made to void the urine, the individual is compelled to wait for several minutes and to strain with the abdominal muscles before the urine appears; and then the stream is not strong and full as usual, but at first slow and weak, so that the urine drops abruptly from the meatus; at the end of urination the stream becomes very small and the act terminates with dribbling. During stupor or unconsciousness from acute diseases, narcotics, or drunkenness, and in cases of injury to the spinal cord, the urine is often retained for many hours unless removed by the watchful physician. Permanent paresis of the bladder may be caused by such retention. Sometimes paresis of the bladder is the direct result of cystitis, apparently because the muscular layers become involved in the inflammatory action and undergo fatty degeneration; it is also a result of the general degeneration of tissues incident to old age, and is a frequent condition in elderly men, even in those who are free from prostatic hypertrophy and urethral stricture.

A slight degree of paresis causes the patient no pain and often no uneasiness; he seeks the aid of a physician because of a feeling that he does not empty the bladder completely and is aware of the necessity for much greater voluntary effort in urinating than was formerly required, or because there suddenly occurs complete retention with inability to evacuate the bladder, or because he is annoyed by a constant and involuntary dribbling of urine. This latter condition usually results sooner or later; but since there is a constant escape of urine and no pain, even the physician as well as the patient may mistake entirely the nature of the case, regarding it as "incontinence of urine" or irritability of the bladder. Such patients frequently tell the physician that they are compelled to urinate fre-

quently because the bladder is so small; that upon the slightest exertion, such as laughing, coughing, or sneezing, an involuntary escape of urine occurs. This is really a condition called by Civiale "stagnation with overflow;" for palpation reveals an enormously distended bladder, and upon introduction of the catheter several pints of urine are evacuated—much to the astonishment of the patient, who has been complaining of the diminutive size of his bladder. Yet frequent dribbling of urine may occur without habitual over-distention of the organ; if the sphincter also is atonic—a frequent condition in elderly men—a constant dribbling is observed even though the bladder contain but a few ounces of urine.

The diagnosis is usually evident from the history of the case; if any doubt exist, this can be set at rest by an examination of the hypogastric region, which usually shows a greatly distended bladder; the distention may be so great as to occasion a mistaken diagnosis of ovarian tumor, pregnancy, and even ascites. The patient, if a male, may be requested to urinate in the physician's presence; the tardiness and weakness of the stream, its abrupt fall from the meatus, and the pronounced voluntary efforts required to expel the urine, indicate conclusively the state of the bladder; the decisive test is the introduction of the catheter after the patient has exerted his utmost efforts in expelling the urine; it is found that a quantity of fluid, sometimes enormous, still remains in the bladder. Yet decided paresis of the bladder may exist without extreme distention; for if paresis of the sphincter also exists, this permits the escape of urine and prevents retention. Hence it may be that upon introducing the catheter only two or three ounces of urine escape; yet even then the manner of its flow, the slow and abruptly falling stream, indicate very clearly the absence of that tonic contraction which in the healthy bladder forces the urine rapidly through the catheter.

Treatment.—In a certain number of cases paresis of the bladder might have been prevented. The responsibility for its occurrence rests sometimes upon the patient, who has by constant neglect to urinate at proper intervals caused the overstretching and consequent loss of power of the detrusor muscles; in many other instances upon the physician, who has neglected to secure regular withdrawal of the urine while treating patients for conditions in which volition is partly abolished. Careful attention to the bladder should be a regular feature in the treatment of all exhausting diseases with or without a loss of consciousness on the part of the individual—typhoid fever, small-pox, apoplexy, coma, etc.; in cases of tabes dorsalis, and myelitis, in which an impairment of the muscular power or voluntary control of the bladder may be expected; and after confinement, operations or injuries involving the pelvic viscera.

After the condition is once established, the treatment should secure the removal of the cause whenever this may be possible. The next indication is to relieve the stretched and atonic detrusor muscles from the former influence of habitual retention of urine; this is to be accomplished by the regular use of a surgically clean catheter, whereby the accumulation of the urine is prevented. Yet caution is necessary, particularly at the very beginning of catheterization. In many cases, even when the bladder is greatly distended, the organ can be completely emptied without ill effect; but in many others, especially those in which hypertrophy of the vesical muscles has been induced by a mechanical impediment to the evacuation of urine, the greatest care must be taken to prevent the immediate and complete evacuation of the bladder. These are the cases in which cystitis, cysto-pyelitis, nephritis, profuse hemorrhage from the entire

urinary tract, syncope, and even death are produced by the complete withdrawal of the urine, however carefully and skilfully the operation is performed. Certain precautionary measures are therefore absolutely imperative in many instances of vesical paresis ; and since it is impossible to predict in what cases these measures can be safely neglected, the only safety lies in adopting them for all.

These precautionary measures consist essentially in keeping the patient in bed and the prevention of the sudden and complete evacuation of the bladder. If the quantity of retained urine can be estimated by a physical examination, the catheter should be withdrawn when not more than half of this quantity has escaped ; and this should be replaced by half its bulk of boracic acid solution (one to thirty). In the course of five or six hours a somewhat greater percentage may be evacuated and partially replaced as before by the boracic acid solution. By gradually increasing the proportion of urine withdrawn, the bladder can be in the course of one or two days completely evacuated without producing the disastrous effects already mentioned. Some surgeons advocate the retention of the soft catheter during this time, so as to avoid the irritation of its repeated introduction ; yet the danger of ammoniacal cystitis is immensely increased by tying in the catheter, so that this measure should never be employed.

After the bladder has been thus gradually accustomed to the absence of distending urine, it should be protected against distention by the regular use of a catheter every three or four hours. This measure is sometimes of itself sufficient to restore the natural tone to the muscular fibres, so that it may be gradually discontinued and finally omitted. Yet in most cases additional means are required and in some all treatment fails, so that the habitual use of the catheter is a permanent feature of the case ; such is necessarily the history when prostatic enlargement has originated the difficulty.

The measures which sometimes assist in the recovery of the muscular tone are the use of electricity and injections of cold water, locally ; atropia, ergot, and strychnine internally. In those cases in which complication with cystitis has been avoided, the local effects of a cold douche may be obtained by successive injections of water into the bladder. The amount injected should not exceed four or five ounces ; the temperature should be at first 30° to 33°, and may be gradually decreased, during three or four successive injections at the same sitting, to 25° or 20°. The colder injections should be retained not more than a few seconds. The cold douche to the hypogastrium, lumbar region, and perineum may be useful. The injection into the bladder of one-sixth to one-half a grain of strychnine, dissolved in water, is said to have succeeded after other measures had failed.

In a limited number of cases decided benefit has been derived from electrical treatment. Erb recommends especially the percutaneous method : he places the positive pole over the sacrum, the negative above the symphysis and upon the perineum (where dribbling indicates paresis of the sphincter). A more efficient method consists in the introduction of an electrode in the form of a catheter into the bladder, where it is brought into contact with different parts of the surface, while the other pole is placed successively over the symphysis, over the lumbar vertebræ, and on the perineum or even in the rectum. This method requires the greatest care, and should not be employed until the bladder has become fully accustomed to complete evacuation by the catheter ; otherwise a violent suppurative cystitis is readily induced ; only very mild currents, either galvanic or Faradic, should be used. This method is especially successful in hyster-

ical and nervous patients; in a considerable number it appears absolutely devoid of benefit.

Internal medication sometimes produces decided benefit: the administration of acids or alkalies, as the reaction of the urine may indicate, may have a good effect upon the condition of the bladder; strychnine and strophine may improve the condition of the muscles. Ergot internally and local injections of ergotin into the perineum, or even from the rectum into the prostate, are sometimes useful, especially when there is prostatic hypertrophy. The tincture of cantharides in full doses (five to ten minims) has occasionally produced an excellent effect. As a last resort a complete change of habits and residence has sometimes effected remarkable improvement where other measures have failed.

Should enuresis exist and persist in spite of all treatment, the patient should wear a recipient, whereby the offensive odor otherwise emanating from the clothing saturated with quickly decomposing urine, can be abolished, and the patient can again enter the society from which he may have long been an exile.

In a few obstinate cases Frisch has completely relieved female patients and restored the action of the sphincter by excision of pieces of the urethro-vaginal septum.

Incontinence of Urine.

The involuntary escape of urine from the bladder is a symptom the cause for which must be carefully sought. While it may occur at any period of life it is especially common in childhood and in old age. In the great majority of adult cases it is a symptom of retention; the patient suffers, perhaps unconsciously, from prostatic hypertrophy or urethral stricture, in consequence of which dilatation and hypertrophy, perhaps paresis of the bladder, exist. In such cases palpation of the bladder shows—often to the patient's astonishment—that notwithstanding the constant dribbling of urine the bladder is more or less distended. The introduction of a soft catheter, after the patient has evacuated the urine to the best of his ability, demonstrates the retention; the quantity withdrawn may amount to several pints. As already stated in discussing paresis of the bladder, care should be taken to permit only a portion of the retained urine to escape; the treatment of this form of incontinence consists in regular and systematic use of the catheter according to the principles already explained.

In comparatively rare cases incontinence without retention of urine is seen in adults; the bladder remains constantly empty. This condition is an occasional feature of "irritability of the bladder" and is produced by the same causes—excessive sexual indulgence or excitement, chronic prostatitis, phimosis, contractions of the meatus or of the urethral channel (strictures of large calibre), irritation of the anus or rectum, etc.; also by mental tension (in students before examination, for example), and by malarial infection; Gross records one case and quotes another in which a periodical incontinence was attributed to malarial influence and promptly relieved by quinine, although no chills nor sweats were observed. The incontinence which frequently occurs during the early months of pregnancy is probably of reflex nervous origin.

Whenever, therefore, an adult complains of dribbling of urine, it is extremely probable that retention exists; the physician's first care should be to determine this point. If the bladder contain no residual urine, a careful examination of the entire area supplied by the pudic nerve—anus, per-

ineum, as well as the genital organs proper—should be made; the urethrometer or the endoscope may reveal an abnormality of the urethra such as a slight constriction or a polyp, in obscure cases.

Incontinence of urine in children often exists without discoverable abnormality of the urinary apparatus. The etiology varies in different cases, and is often quite obscure. The attempt to refer the disorder generally to scrofula, rachitis, etc., has not been successful; the subjects are frequently in robust health. It is certain that general debility favors the temporary occurrence of enuresis; it may arise suddenly during acute illness and disappear with convalescence; it is also favored by mental or emotional strain. The important rôle which cerebral influences may play in producing enuresis is shown in the occasional epidemics of the difficulty which prevail temporarily in asylums and boarding-schools for children. In general it is assumed that there exists some defect in innervation: an insufficient sensibility—anæsthesia—of the vesical nerves; a spasm of the detrusor muscles; deficient innervation of the sphincter muscles; a congenital deficiency of the sphincters, etc. These are, however, mere hypotheses based upon the symptoms and the results of treatment.

In a certain number of cases the vesical incontinence can be traced to the mechanical irritation of the urinary or adjacent organs. Thus it is a direct consequence of phimosis, stricture, inflammatory affections of the vulva and rectum; like vesical irritability in adults, the incontinence of children can be caused by cystitis, pyelitis, calculi in the pelvis or in the bladder, and even by the contact of acid and concentrated urine. These cases are usually considered to be rare; yet this opinion is probably based rather upon a failure to investigate thoroughly than upon actual negative demonstrations. I remember seeing, for example, a ten-year-old boy, patient of Dr. Englisch, in Vienna, who had been for years the subject of continual incontinence, for which he had been treated with belladonna, ergot, and the other usual remedies without success. A stricture—apparently organic and congenital—was finally discovered at the bulbomembranous junction; gradual dilatation of this stricture produced an immediate and permanent cure. It is quite possible that a more careful search for anatomical and urinary abnormalities might diminish materially the number of obscure and obstinate cases. In a personal case, after the usual remedies had failed, an inspection of the vulva showed two minute polypoid excrescences just within the meatus; the removal of these with the scissors was followed by immediate cessation of an annoying enuresis.

The *treatment* of incontinence in children should not consist in a promiscuous and routine prescription of belladonna or other drug. It should begin with an examination of the urine, and if this be found normal, with an inspection of the genital and neighboring organs. By palpation of the abdomen it is ascertained whether or not the bladder is empty; for although habitual retention of urine is unusual in children, it is a possible occurrence as the result of tight phimosis, contracted meatus, or other urethral obstruction. The manual examination may suffice, at least temporarily; the introduction of sounds or specula is not necessary until internal remedies have been tried unsuccessfully.

If no anatomical nor urinary abnormalities are discovered, remedies addressed to the individual as well as to the bladder may be employed. For it will be noticed that the sufferers from incontinence exhibit radically different physical and mental characteristics; some are distinguished by constant activity of body and mind, though not necessarily nervous or feeble. Such children are apt to have involuntary evacuations of urine during

I am therefore in the habit of using the method recommended by Ultzmann. One pole consists of an insulated metallic rod as thick as a lead-pencil and three or four inches long; this, well oiled, is introduced into the rectum. The other pole is an ordinary sponge, which is placed on the raphé of the perineum in boys, and in a gluteal fold in girls; the latter pole can be subsequently transferred to the lumbar region and over the symphysis. The current must be at first very weak, scarcely perceptible to the patient, in order not to alarm him and thus provoke a struggle. The sitting should be at first three to five minutes and gradually lengthened to double that period; it should be repeated daily for several weeks, and may ultimately be successful even at the end of two or three months. Relapses are apt to occur after the treatment is discontinued, but can always be relieved by its renewal.

The success of this treatment is often surprising; indeed, no case should be considered incurable until electricity has been fairly tried. In one instance, a nine-year-old boy, I was thus enabled to arrest by three applications a nocturnal incontinence which had existed since infancy; and Rossbach mentions a case in which the same method of treatment was successful in relieving enuresis of twenty years' duration. It must, however, be admitted that there are cases which resist this as well as all other remedial measures.

The introduction of bougies or metallic sounds, which are permitted to remain for two to five minutes at a time, has occasionally succeeded where internal medication has failed, and may be tried in boys for a short time. This method has the disadvantage of occasionally causing (when long continued) an inflammation around the neck of the bladder or even in the epididymis. Local cauterization of the urethra, notwithstanding the favorable reports which have been recorded, should never be practised; Trousseau's "compressor of the prostate" and all other mechanical devices for preventing incontinence, are useless and objectionable; the use of collodion for sealing the meatus is merely palliative, and undesirable except in extreme cases.

In all cases abstinence in eating, and particularly in drinking, should be observed during the latter part of the day; constipation is to be avoided, and the bladder emptied before retiring; a warm or cold bath in the evening is desirable; the child should sleep on a hard bed. The practice of awakening the individual one or more times during the night is rarely profitable, since in many instances the bladder is evacuated shortly after the child falls asleep and not thereafter.

In every instance the failure of these usual measures should be followed by a careful examination of the urine as well as of the pelvic organs, whereby there may be discovered a source of irritation productive not only of the enuresis, but also of more serious and permanent derangements.

DISEASES OF THE MALE SEXUAL ORGANS.

CHAPTER XX.

PROSTATIC DISORDERS.

Prostatitis.

Inflammation of the prostate may be primary or secondary, acute or chronic. A primary acute prostatitis is rare and is probably caused exclusively by wounds (false passages with the catheter) or chemical irritants applied through the urethra. Excessive and prolonged sexual excitement suffices for the production of a chronic prostatitis.

The acute form is produced usually by the propagation of a previous inflammation—gonorrhœa, cystitis, urethritis secondary to a stricture; occasionally it seems to follow exposure to cold, extreme acidity of the urine, and the use of acrid remedies, such as cantharides; it is highly probable that in each of these latter cases the cause named is assisted by the influence of a previous gonorrhœa, venereal or dietetic excesses, etc. The injection of irritants or the application of caustics to the prostatic urethra is also productive of the affection. Like other diseases of the sexual organs, acute prostatitis is chiefly observed during the period of greatest sexual activity; in children and in old men it is rare.

Symptoms.—Frequent and painful urination and severe pain referred to the perineum are the early symptoms. These increase in severity and are accompanied by a feeling of weight and dragging in the genitals and the lower part of the abdomen. Rectal tenesmus is soon added; the patient feels something protruding into the rectum and endeavors to evacuate the bowels frequently. The inflammation may be ushered in with a chill, and fever is a usual feature. The patient cannot assume a sitting posture with comfort; he lies with the thighs separated, carefully avoiding every movement which can aggravate the pain that soon radiates over the whole lower portion of the trunk and along the thighs. Urination becomes more frequent, painful, and difficult; the swelling of the prostatic urethra may finally cause complete retention and require the use of a soft catheter; the patient's efforts to empty the bladder by contracting the abdominal muscles merely aggravate the pain and increase the swelling; a little blood may appear at the end of each micturition and often in the intervals when the bladder is contracted; pain is felt behind the symphysis, along the urethra, and especially at the meatus and in the fossa navicularis; the

passage of urine occasions a severe scalding pain along the urethra ; the urine contains mucus, pus, and blood. Priapism and seminal emissions occur. The perineum is sensitive to pressure ; the finger introduced into the rectum meets a tense, hot, extremely sensitive tumor, which often pulsates distinctly. The slightest touch is painful and excites an urgent desire to urinate.

If the prostatitis occur as a result of gonorrhœa (the usual cause) the purulent urethral discharge immediately ceases and is replaced by a clear, viscid, slimy secretion, which proceeds not from the prostate, as is usually stated, but from the urethral glands. With the subsidence of the prostatic inflammation the gonorrhœal discharge reappears (Fig. 22).

FIG. 22.—Gonorrhœal Discharge : Epithelial Cells and Pus-corpuscles containing the Characteristic Micrococci, which are seen imbedded in the cells and free.

Acute prostatitis may terminate in resolution, which takes place in eight or ten days ; or in a chronic inflammation, which may cause permanent enlargement and induration of the gland, or finally in suppuration. If resolution occur recovery is complete in two to four weeks ; if the disease become chronic the patient is apt to experience various unpleasant and even painful sensations connected with the genital and urinary functions ; the (pseudo) hypertrophy which remains can often be reduced by ergot, electricity, and other remedies, wherein it is distinguished from the non-inflammatory hypertrophy of old age. When suppuration occurs the issue of the case is extremely doubtful ; the initial chill and fever which mark the beginning of pus formation may be followed by irregular chills, sweats, emaciation, and indeed all the symptoms of fatal pyæmia. In favorable cases the abscess breaks spontaneously, within a week, into the urethra or bladder ; the severe symptoms cease, the abscess cavity granulates and cicatrizes ; or atrophy of the prostate and a permanent suppurating surface may remain. Perforation may occur into the rectum, through the perineum, and even into the peritoneal cavity ; hence various

fistulæ and (in the latter case) fatal peritonitis may result. Zeissl saw double perforation into bladder and rectum, resulting in the escape of urine through the rectum and of fæces and intestinal gases into the bladder.

The *diagnosis* is usually plain; though at first the affection may be regarded as acute cystitis, yet a digital exploration of the rectum reveals such tenderness (not necessarily great enlargement) of the prostate as serves to localize the inflammation; vesical tenesmus is less pronounced than in cystitis; the latter is, however, an occasional complication. Zeissl calls attention to the possible confusion with an ischio-rectal abscess; this is recognized by the lateral position of the swelling, the absence of great prostatic tenderness and of extreme urinary difficulties.

Periprostatic abscesses are sometimes formed during gonorrhœa or from stricture. The symptoms are those of acute prostatitis, but less intense; the finger in the rectum distinguishes œdema around the prostate; distinct fluctuation may be apparent. There is at first but little difficulty in urination, though retention may ultimately occur.

Treatment.—Acute prostatitis is a serious affection and must be promptly and energetically treated; among one hundred and four cases collected by Segond, thirty-five terminated fatally. The essential items of treatment are absolute repose and opium. The patient must remain in bed; the hips may be elevated upon a cushion; anodynes, morphine and belladonna, should be given in such quantity as to control the vesical tenesmus as well as the pain; these are best administered as rectal suppositories. If seen during the first forty-eight hours, ten or twelve leeches may be applied to the perineum, and the bleeding prolonged by fomentations. Rectal evacuations may be secured if necessary by enemata of hot water; laxatives are not required. The urine should be rendered alkaline; hot fomentations should be constantly applied to the perineum and over the pubes; a hot bath or hot hip-bath should be administered at least once daily, care being taken that the patient does not walk to nor from the bath. A most efficient and soothing method of applying heat and moisture to the inflamed gland is the injection of hot water through a soft catheter introduced only into the membranous urethra. Only two or three ounces should be injected at a time, because of the pain otherwise produced by the distention of the irritable bladder; the temperature, at first 95° to 100°, may be gradually increased during successive injections to 120°; these injections may be repeated three or four times daily. The continuous application of hot water, so useful in acute cystitis, might be beneficial; I have as yet no experience with it in acute prostatitis.

In spite of the frequent urination, retention of urine is apt to occur, because the swelling of the prostatic urethra offers a decided impediment to urination; it should be looked for and relieved by the cautious introduction of a soft catheter, a measure always attended with severe pain and often difficult; Dittel advises that if the swelling be so intense as to render the introduction of the catheter very difficult, the instrument be permitted to remain. If the prostate be much swollen, it projects in the rectum over the membranous urethra and approaches the sphincter ani; this condition causes severe and constant rectal tenesmus; under these circumstances König advises that the anal sphincter be divided, so as to diminish the pain and prevent the formation of tortuous fistulæ.

So soon as abscess formation is suspected, either from the symptoms or from palpation, a silver catheter may be gently passed into the prostatic urethra in the hope of securing an outlet for the pus into this chan-

nel ; if such attempts are unsuccessful, and if fluctuation becomes apparent in either rectum or perineum, the pus should be evacuated. Through the rectum an opening is made by means of a trocar ; if made from the perineum, as advised by Diday, a straight, narrow bistoury should be inserted in the raphé about three-fourths of an inch in front of the anus, and pushed toward the prostate, which is meanwhile supported by a finger in the rectum.

Chronic Prostatitis.

Our knowledge of this affection is by no means complete, and the general impressions with regard to it are certainly inaccurate. By many practitioners its existence is virtually ignored, while by certain specialists it is assumed to exist in cases where obscure symptoms of the genital organs cannot be otherwise explained. The slight, turbid discharge which often proceeds from a chronically inflamed prostate and is pressed out especially during defecation, is often considered evidence of "spermatorrhœa," while, on the other hand, the slight gleet which may be caused by a stricture of larger calibre than the meatus (and hence escape detection by the sound) or a true spermatorrhoea is considered a prostatic discharge. Even such acute observers as Gross and Ultzmann have regarded as evidence of chronic prostatitis the transparent, viscid fluid which is secreted by the urethral glands, especially during sexual excitement, but which does not proceed from the prostate. The clinical investigation of the disease is certainly difficult ; indeed, in some cases chronic prostatitis is found post-mortem where no symptoms suggesting its existence have been complained of.

Etiology.—The most frequent causes are gonorrhœa, stricture, and sexual excess or excitement ; ammoniacal fermentation in the bladder, following the use of the catheter in the subjects of prostatic hypertrophy, may also produce it. It is occasionally a sequence of acute prostatitis.

The *Morbid Anatomy* has been rarely studied post-mortem ; during life it is found that the gland is sometimes of normal size, sometimes enlarged and hard (probably from coincident hypertrophy), and again enlarged and soft. Cysts which contain a thick, yellowish, viscid fluid (prostatic secretion), pus and concretions, are not uncommon. In a certain proportion of cases tuberculosis with caseation is found affecting the gland and other genito-urinary organs.

Symptoms.—These are by no means constant nor characteristic. They are usually described as a feeling of weight and heat in the perineum, frequent urination accompanied with unpleasant and even painful sensations at the neck of the bladder and along the urethra, pain during seminal ejaculation ; the appearance of a few drops of blood at the end of urination and perhaps mixed with the seminal discharge. Even when these symptoms are present, they may indicate a vesical calculus or tumor, or a stricture with chronic urethritis, as well as a chronic prostatitis ; indeed, some of these features are sometimes seen as the result of simple prostatic hypertrophy. A history of gonorrhœa or the existence of gleet increases rather than diminishes the difficulty of differential diagnosis.

In many cases several of these symptoms are absent ; while none are constant, the sense of weight in the perineum, pain around the neck of the bladder and along the urethra, and the appearance of threads in the urine are probably the most frequent symptoms. If chronic suppuration exist, difficulty in urination sometimes amounting to absolute retention, may

occur suddenly, or dribbling of urine may be noticed—probably, as Socin suggests, in consequence of the filling of the abscess cavities with urine. Pollutions or spermatorrhœa are frequent symptoms, and the patient is often despondent and dejected.

A symptom to which undue prominence is usually given is the so-called *prostatorrhœa.* For in a considerable number of cases there is absolutely no discharge from the urethra; the catarrhal products of the prostatic inflammation are prevented from escaping by the tonic contraction of the membranous urethra (external sphincter). In such instances these products escape through the meatus only when washed out with the urine during the act of micturition or forced out during defecation. They appear as short, thick threads, often provided with a thickened, headlike extremity; these are expelled with the first gush of urine. Pressure upon the prostate from the rectum does not necessarily cause their appearance at the meatus; hence a negative result upon such pressure does not, as usually stated, exclude the existence of chronic prostatitis.

The term prostatorrhœa is, moreover, frequently misapplied to other liquids than prostatic secretion which appear at the meatus. As Fürbringer has shown upon the basis of extended clinical and anatomical examinations, the secretion of the prostatic follicles is *always,* in health and in disease, *turbid* or milky from the presence of numerous granules; hence it is a mistake to regard as prostatorrhœa the appearance at the meatus of a clear, viscid fluid, which is usually observed during sexual excitement in healthy males, and is found in the subjects of sexual irritability after every amorous thought. This fluid is produced not by the prostate but by the urethral glands. There may be, it is true, a simultaneous secretion from the prostatic follicles; if this passes through the membranous urethra (which is seldom the case) the liquid that appears at the meatus is no longer clear, but turbid or milky. In several cases I have carefully investigated this subject; I find that while the fluid at the meatus is often clear and transparent, the first drops of urine passed at the next act of micturition and caught in a separate vessel, contain a gelatinous, turbid mass, which upon microscopic examination is found to contain granules, leucocytes, and frequently amyloid bodies and stratified epithelium characteristic of the prostate. The clear fluid was the secretion of urethral follicles, while the turbid mass proceeded from the prostate, but was prevented from escaping by the membranous sphincter.

The discharge which proceeds from a localized gleet (Fig. 23) is doubtless sometimes considered prostatorrhœa; especially when no accompanying stricture is detected (either because none exists or because it is of such large calibre as to escape detection by the ordinary sound). It is quite probable that a genuine spermatorrhœa is also frequently considered a prostatic secretion—prostatorrhœa; for seminal incontinence without ejaculation is not so rare as is generally taught; it is found unexpectedly in vigorous subjects who have no abnormal pollutions, but have had gonorrhœa.

The discharge furnished by a chronic prostatitis—prostatorrhœa—is turbid, thick, having the characters of mucus, muco-pus, or pus, according to the intensity of the catarrh; it resembles, therefore, the discharge of gleet. The amount may vary from a quantity merely sufficient to keep the meatus moist to several drachms per day (Socin). The flow may be continuous or intermittent; the amount discharged is much increased during defecation and micturition; sometimes the linen is stained just as by a gleet. Upon microscopic examination there are found pus and occa-

sionally blood-corpuscles, numerous granules of fat and pigment, and sometimes characteristic amyloid bodies and cylindrical epithelium. Short threads, consisting largely of pus-corpuscles, are often seen in the urine, both at the beginning and at the end of micturition.

Upon rectal examination the prostate is found quite sensitive, sometimes also slightly enlarged; after pressure with the finger there may appear at the meatus a quantity of turbid discharge, identical in all characteristics with that which escapes spontaneously. In rare cases the fluid of a prostatorrhœa is found to consist of the normal prostatic secretion; this is thin and watery in consistence but of milky appearance.

FIG. 23.—Discharge of a Gleet: Thread composed of Pus corpuscles and Epithelial Cells.

The *prognosis* is very uncertain and varies with the cause of the prostatic inflammation. The least obstinate cases are secondary to urethral stricture and vesical stones; when produced by masturbation or venereal excess, the disease can be often controlled after the exciting cause is discontinued; yet in general, while occasioning no danger to life (unless suppuration exists), the morbid condition is extremely persistent.

Diagnosis.—The recognition of chronic prostatitis is sometimes easy, but often difficult. A history of gonorrhœa or sexual excess, a feeling of weight and tension in the perineum, hyperæsthesia of the urethra, painful sensations at the neck of the bladder, especially at the close of urination, the appearance of threads at the beginning and at the end of urination, a slight flow of blood with the last drops of urine, tenderness of the prostate upon rectal and urethral examination—a combination of these symptoms renders a diagnosis positive. Such typical cases are, however, unusual; and even when some of these symptoms are present, great care is necessary to exclude stricture and gleet, and spermatorrhœa. If there be a history of gonorrhœa, as is usually the case, the calibre of the urethra should be explored with bulbous sounds or the urethrometer. If prostatorrhœa is noticed, the liquid should be carefully examined with the micro-

scope as well as macroscopically. A thin milky liquid, increased by pressure upon the prostate from the rectum, is the normal prostatic secretion, and constitutes, therefore, strong evidence that no prostatitis exists. The fluid furnished by a chronic prostatitis is, as already stated, thick, slimy, often increased by pressure upon the prostate; under the microscope there are seen leucocytes, stratified amyloid concretions, and numerous cylindrical epithelial cells; these sometimes exhibit the characteristic arrangement—a double layer, the outer ones large with long extremities which are inserted into a mosaic of small round cells, constituting the second layer (Fig. 24). Occasionally casts of the prostatic follicles, composed of the epithelial lining, are found; this is a rare occurrence; the threads which frequently appear in the urine are not composed of such casts, as many of the books state, but are simple masses of leucocytes with

FIG. 24.—Prostatic Discharge (Prostatorrhœa): Stratified Epithelium from the Prostate, Amyloid Bodies, Prostatic Granules, Leucocytes, and Spermatic Crystals.

some epithelial cells. The presence of the amyloid bodies is not absolutely characteristic of prostatic secretion, since a few of these masses are sometimes furnished by the urethral glands, especially when inflamed. Moreover, even the prostatic secretion does not always contain them; yet their presence in large numbers is practically significant of prostatic inflammation.

The distinguishing feature of the prostatic secretion is the "spermatic crystal" described by Böttcher (Fig. 24). These bodies are compounds of phosphoric acid (perhaps also magnesia) with an albuminous base discovered by Schreiner; this albuminous substance is found only in the prostatic secretion; hence the presence of its crystalline compound (Böttcher's crystals) proves that the substance under examination is or contains prostatic secretion. They can therefore usually be found in semen, because of the admixture with the secretion of the prostatic follicles; but are not found in the secretion of either testicle, seminal vesicle, or urethra. If normal semen be allowed to stand, these crystals are found on the second

or third day, first in small numbers, but rapidly increasing ; they are clear, transparent, rhomboidal, and when first formed somewhat blunted. They can be more conveniently procured by adding to a drop of semen on a slide one drop of a one per cent. watery solution of ammonium phosphate. In an hour or two very large and numerous crystals are formed as a rule ; sometimes it becomes necessary to permit all the liquid to evaporate, when the crystals will be found near the edge of the cover-glass. These crystals can usually be produced from the spontaneous discharge of true prostatorrhœa ; yet in some cases it is impossible to discover them either by permitting the fluid to settle or by the addition of ammonium phosphate. These are cases in which the prostatic discharge is mixed with pus, either from a gleet, suppurative prostatitis, or cystitis ; or in which the secretory activity of the gland is arrested (as in atrophy after gonorrhœa). Contact with the urine prevents their formation ; hence they cannot be discovered in the urinary sediment, nor in those cases in which an insufficience of the vesical sphincter permits the urine to escape continually into the prostatic urethra.

The discovery of these crystals proves, therefore, that the liquid under examination contains prostatic secretion. It then remains to be decided whether this secretion alone is present, or whether other discharges are mixed with it. If the contents of the seminal vesicles are also contained in the discharge—as in true spermatorrhœa—numerous spermatozoa are seen ; it must be remembered, however, that a *few* of these cells may be present in simple prostatorrhœa, as a result either of recent ejaculation or of straining during defecation ; also that in cases of azoöspermism no spermatozoa are discharged. In the former case—recent ejaculation—the history explains the presence of spermatozoa ; in the latter—azoöspermism—the microscope may fail to recognize the admixture of semen with the prostatic secretion.

If no spermatic crystals can be detected, the recognition of the prostatic origin of a urethral discharge rests upon the presence of numerous amyloid bodies, stratified cylindrical epithelium, and possible casts of the prostatic follicles ; the ejaculated semen contains, if chronic prostatitis exists, numerous leucocytes, the product of the prostatic catarrh ; blood-corpuscles are also frequent. If, therefore, the semen obtained by ejaculation be quite normal and free from pus and blood, chronic prostatitis can be excluded.

A constant discharge from the meatus, even when turbid and increased by pressure upon the prostate through the rectum, does not prove the existence of chronic prostatitis ; for such discharge may originate in the urethra (gleet), may be a true spermatorrhœa, or finally a secretion from the normal prostate (in this case it is thin and milky).

Sensitiveness of the prostate upon pressure through the rectum and contact with the urethral sound are positive, though not constant symptoms ; since the passage of a sound causes an unpleasant or even painful sensation in the normal prostatic urethra, it is occasionally impossible to decide by this measure whether or not the prostate is inflamed.

If the source of a supposed prostatic discharge cannot be determined in other ways, the secretion of the prostatic urethra can be collected and isolated by introducing an endoscope or porte-remède, withdrawing the conductor and inserting a camel's-hair pencil, which can be made to sweep the prostatic surface and then withdrawn. In this way sufficient material can be obtained for microscopic examination and comparison with the spontaneous discharge.

Treatment.—This must usually be both general and local; the former is sometimes successful where local applications have failed. The exciting cause should be in every case ascertained; while this is usually gonorrhœa, yet the possibility of an additional irritation, such as phimosis, hæmorrhoids, or stricture, should be remembered. The patient is, moreover, often the subject of neurasthenia, induced largely by the mental depression and anxiety which usually accompany the prostatic difficulty; hence quinine and iron, strychnine and phosphoric acid may assist materially in the treatment of chronic prostatitis, as they often do in the later stages of an obstinate gonorrhœa. Cases are recorded, indeed, in which change of climate and occupation has cured a previously intractable case. The patient is usually melancholy and despondent, especially if, as is often the case, nocturnal pollutions are frequent; the physician should therefore, as an important preliminary to treatment, gain his confidence by tact and sympathy and by dispelling his exaggerated fears as to the gravity of the complaint.

Whenever there is a history of gonorrhœa a careful exploration of the urethra should be made; since even a stricture of large calibre, not detected by the ordinary sounds, is sufficient to prolong and intensify, possibly to originate, a chronic prostatitis.

The *local* treatment includes the avoidance of all influences which tend to maintain or aggravate prostatic congestion; hence daily evacuation of the bowels must be secured; the urine should be only faintly acid and not concentrated; walking and riding, when they produce or aggravate pain in the perineum, should be avoided; sexual excitement may be permitted only at intervals of ten days or two weeks; the usual injunction to abstain entirely from intercourse is irrational, since continence maintains a continual, though perhaps slight congestion of these parts.

Decided though temporary improvement is obtained by the application of flying blisters to the perineum; for this purpose most authors recommend cantharides, either as plaster or collodion. To avoid the possible irritating effects upon the bladder and prostate I am in the habit of employing French mustard leaves, which are permitted to remain only long enough to redden the surface distinctly. These may be applied to different parts of the perineum at intervals during several hours in the day. Warm hip-baths should be administered once or twice a day; and if there be constipation, warm enemata will not only secure an evacuation of the rectum but also benefit the prostate directly.

Internally the bromide of potassium is a most valuable agent. During the day it can be administered only in small doses because of the drowsiness otherwise produced, but at night a full dose (forty to sixty grains) should be given combined with ten grains of potassium bitartrate (Rosenthal). Full doses of ergot and atropia have produced excellent results in individual cases, usually vigorous subjects.

The most effectual measures are those addressed directly to the prostate through the urethra. Foremost among these is the daily use of a steel sound, which is permitted to rest in the urethra for five or ten minutes unless the patient complains of pain. At first sounds of medium size, No. 8 to No. 10 English, should be employed; but larger instruments should be successively introduced until the full calibre of the meatus is attained: if this be small, it should be enlarged so that a No. 14 or No. 15 can be introduced. Instead of sounds the psychrophor of Winternitz may be employed; this is merely a closed catheter through which a constant current of water can be passed. The temperature should be at first about 60° F. and the sitting last three to five minutes; the water may be

gradually cooled to 50° or even 45° F., and the sitting prolonged to ten minutes. Occasionally the urethra is so sensitive that the introduction of a sound causes extreme pain; in this case the use of the sound should be postponed until the urethral hyperæsthesia is diminished by the bromides internally and by the injection of warm water through the prostatic urethra.

Astringent injections are best made by means of Ultzmann's prostatic catheter; it is scarcely necessary to say that an injection made from the meatus rarely reaches the prostatic urethra because arrested by the contracted sphincter at the membranous portion. Ultzmann's instrument is a short catheter perforated at the extremity by several circular or longitudinal openings, whereby the liquid is ejected to all parts of the canal. A shoulder at the outer extremity prevents insertion beyond the prostatic urethra. When the point is introduced well into the membranous portion, the liquid injected passes through the prostatic urethra and into the bladder.

For the purposes of this injection the following solutions may be used: Water heated to 100°, with or without hydrastis; one-half to two per cent. solution of tannin in glycerine and water; one-half to one per cent. solution of the sulphate of zinc; if these make no perceptible impression solutions of nitrate of silver may be cautiously employed. Such solution should be at first not stronger than two or three grains to the ounce, but may be gradually increased to ten or even fifteen grains.

These remedies can be applied more efficiently, perhaps, in the form of bougies of cocoa butter; these are introduced into the prostatic urethra through the porte-remède of Dittel or Harrison; the soluble prostatic bougies made by Mitchell, of Philadelphia, have usually been satisfactory in my hands. By such means some of the symptoms of chronic prostatitis, especially the prostatorrhœa, can usually be relieved; yet the uneasy sensation at the neck of the bladder, the hyperæsthesia of the urethra often persist, and indeed are sometimes practically incurable. It is probable that the obstinacy of the affection is often dependent upon a coexistent catarrh of the ejaculatory ducts and seminal vesicles, which are inaccessible to local remedial measures.

CHAPTER XXI.

FUNCTIONAL DISORDERS.

More labor has been spent in writing about, though but little in investigating, those morbid conditions which are manifested by the so-called "functional" disorders of the male sexual organs. The voluminous literature of the subject is restricted largely to a narration of cases in which the chief symptoms are pollutions, spermatorrhœa, etc.; the stereotyped etiology is comprised in masturbation and venereal excesses; the routine treatment consists of the bromides, aphrodisiacs, steel sounds, exhortation, and marriage. So long as this practice prevails; so long as pollutions, impotence, and spermatorrhœa are regarded and treated as diseases rather than as symptoms of the most diverse morbid conditions (of many others as well as of the genital organs) the treatment must remain as unsatisfactory as it is to-day, furnishing occasionally a brilliant success, often entirely barren of good results, and sometimes even aggravating materially the patient's condition.

It must be confessed that our knowledge of those various morbid states which are manifested by the so-called functional diseases of the male sexual apparatus is by no means exhaustive nor even extensive; they have not been made the subject of such systematic anatomical and clinical research as must precede the development of satisfactory knowledge. They are brought to the notice of the general surgeon or of the general practitioner; by the one they are referred to local disease, by the other to a morbid imagination or to onanism. The attitude of the profession toward these disorders is essentially identical with that maintained toward the diseases of the female sexual organs forty or fifty years ago; during that period the latter maladies have engaged the entire attention of a considerable portion of the profession; the intimate mutual relations between these organs and the general system have been fully appreciated; and now the diagnosis of any obscure complaint in the female includes an inquiry into the state of the sexual functions; and conversely, the treatment of sexual disorders in the female includes the regulation of the general health. However severely we may criticise and ridicule the exaggerations and infatuations of enthusiastic gynecologists, we must admit that their labors have advanced the science and art of general medicine, and have illuminated much that was obscure and unsuspected until the intimate relation between the sexual and other functions was appreciated. There is much in the history of gynecology which we may profitably apply to the study of sexual disorders in the male; although but little study has been devoted to the relations of the male genital organs to the other bodily functions, yet the facts already established indicate a close analogy with the corresponding functions in the female, and justify the belief that further investigation will lead to a broader comprehension, clearer recognition, and more successful

treatment of these disorders in the male. The reproductive functions constitute, it is true, a less prominent factor in the physical life of man than of woman ; yet while the diseases of the uterus are more tangible and apparent than those of the prostate, the subtle influence of such disease upon the functions of other organs is quite as real in the one case as in the other. Hysteria in the female, formerly regarded as a "functional" disease of the nervous system, is now known to have usually an anatomical basis in a disorder of the sexual organs ; so many cases of hypochondria, morbid imagination, abnormalities of the nervous system in the male, are now known to originate in disorders of the sexual organs. "What lacerations of the cervix and perineum, irritations, congestions, and displacements of the uterus and ovaries are to many female nervous symptoms, such are phimosis, redundant prepuce varicocele, irritable testes, urethral contractions, and above all and pre-eminently, irritation and congestion of the prostate and prostatic urethra with spermatorrhœa, to many male nervous symptoms." This statement of Beard's represents probably what will be, rather than what has been demonstrated ; yet enough has been proven to show not only that palpable sexual derangements in the male should be more carefully studied, but also that the investigation of obscure complaints in the male should not, as heretofore, omit all inquiry into the condition of the genital organs and functions.

A morbid influence exerted by these organs is not always thrust upon the attention by the occurrence of pollutions, impotence, or other symptom of sexual derangement ; a patient may be honestly unconscious of abnormality in his reproductive organs, and yet be suffering severely in general health or special functions from an irritation of the glans (tight prepuce, contracted meatus), from stricture, chronic prostatitis, or seminal incontinence (true spermatorrhœa). Conversely, pronounced symptoms in the genital apparatus—pollutions, impotence—may be merely one manifestation of organic disease in other organs. Hence in practice we should not wait for a complaint of sexual abnormality before investigating the genital organs ; and conversely, though these functions furnish the most prominent or even the only symptoms complained of, we should not confine our search for the cause to abuses of these organs. The reproductive functions are the last to mature and the first to decay ; their perfect performance marks the highest development of the animal ; they are most intimately associated with the general health of the individual, to which they are an accurate index, and upon which they exert a powerful influence for good or evil.

The examination of the male patient should, therefore, as a rule, include an inquiry into the condition of the sexual functions and organs, especially when the cause of the symptoms complained of is somewhat obscure. There are naturally many exceptions to this rule, to be dictated by the tact and discretion of the physician ; yet while there are cases where such inquiry might offend, there are many others where the failure to inquire disappoints the patient and misleads the physician. The former has a lurking suspicion or positive knowledge that the genital organs are concerned, and is anxious that the physician should institute pertinent inquiries ; yet is himself restrained by pride or shame from mentioning a subject which must lead to a confession of sexual sins or abuses. Such patients often hint at the subject by mentioning, in a cursory and indifferent way, slight morbid symptoms manifested by the urinary organs ; if such remarks be properly interpreted, and the clue thus furnished be discreetly pursued, a frank statement of genital derangements follows ; if, on the

other hand, the physician fails to comprehend and appreciate the situation, the patient's lips are sealed on that subject, and he leaves, feeling that the physician does not understand his malady. Then there are numerous cases in which the patient is really ignorant that his ailment is grounded in or aggravated by morbid conditions of the sexual organs; the physician whose examination ignores these organs may treat him long and unsuccessfully for dyspepsia, neuralgia, shortness of breath, palpitation of the heart, or other manifestation of sexual neurasthenia. Finally, there are cases in which sexual derangements are prominent symptoms, a history of masturbation or venereal excess is confessed, and the physician—trained to the habit of regarding onanism as the source of all sexual evils in the male—overlooks other and more potent factors in producing the ailment.

The importance of these organs in their relation to the general health demands at least a general inquiry as a routine part of an examination; the extent to which the investigation should be prosecuted must be determined by the circumstances in each individual case.

The *etiology* of genital disorders is by no means comprised in onanism and sexual excesses. Doubtless these practices cause in some cases, and favor in others, the development of frequent pollutions and impotence; yet the extent of their application is, I believe, much exaggerated by physicians as well as patients; we are still addicted to the habit of ascribing such disorders to masturbation, and consequently of ignoring other important and frequent causes. It is indeed surprising to find how firmly rooted is the general belief that sexual disorders are practically always attributable, wholly or in part, to onanism; even men in middle life, who after performing the genital functions properly for years, suffer from impotence or spermatorrhœa, often refer remorsefully to early masturbation as the source of all their troubles. Thus one of my patients, an intelligent man forty-eight years of age, who had been married twelve years and was the father of three children, had enjoyed perfect sexual vigor until his forty-fifth year, since which time a gradual loss of virility had been observed, culminating in inability to copulate (through feebleness of erection and premature ejaculation) and true spermatorrhœa. The patient bitterly bewailed an early habit of masturbation as the cause of his condition. On inquiry I learned that he had practised the habit about once daily from his sixteenth to his nineteenth year; then for two years he had had one or two pollutions weekly, after which time he had indulged very freely in intercourse for fourteen years, and had twice had gonorrhœa. After his marriage, at the age of thirty-six, he had had almost nightly intercourse for over two years, and had always indulged very freely. Yet notwithstanding his later excesses and diseases, he referred the impotence to early onanism.

Venereal excesses are certainly responsible for many of the ills attributed to onanism, as in the case mentioned. It is of course impossible to make any general statement as to what constitutes excess, since this is a relative and not an absolute term. The amount compatible with health varies much in different individuals, in the same individual at different times and conditions, and with the character of the indulgence; since the exhausting effects result not from the loss of semen but from the attendant emotional excitement, an injurious amount of indulgence is attained by less frequent acts of intercourse when this is illicit than when it is conjugal. Beard refers to a patient, nearly sixty years of age, who consulted him concerning an impairment of sexual power following a fall, after which accident he found himself able to copulate only three or four times a week; when it was suggested that such ability might well be considered satis-

factory, he said "that for all his life he had been accustomed to have intercourse every night." McGraw (quoted by Howe) says: "I do not believe that even a daily emission of semen will do serious damage to a healthy vigorous man. In view of the fact that multitudes of men after marriage have connection with their wives more than once every night without suffering injury, it seems to me an absurdity to ascribe so much evil to seminal losses as is usually done by authors." I was once consulted by a young man of superb physique and health, who during a brief separation from his wife had acquired a soft chancre; he excused his marital infidelity by saying that having been accustomed during the four years of his married life to intercourse at least once or twice every night he was unable to remain perfectly continent for three weeks. On the other hand, I have known a case in which a man of thirty-four, married eight years, suffered from headache, general lassitude, and pain in the loins after each conjugal approach, though this was performed only once in eight or ten days. He admitted that these symptoms had been noticed only during the last year, and that during the earlier years of his married life he had almost nightly intercourse. The effects, both general and local, not the frequency of the act, must decide whether or not sexual indulgence is excessive. It is to be noted that such excess is manifested variously in different individuals; in highly "nervous" and delicate persons it causes the symptoms of general exhaustion, mental depression, and lack of energy, without sexual derangement; in the strong and vigorous, on the other hand, such excess may be manifested solely by impairment of virility, etc., without derangement of other than the sexual functions.

Gonorrhœa is a not infrequent cause of functional sexual disorders. Its injurious influence is exerted sometimes through the formation of strictures, which even when of large calibre and unrecognizable by the cylindrical sound, may at least aggravate and maintain, and perhaps provoke, pollutions, painful and feeble ejaculation (sometimes the earliest symptom of stricture) and premature emissions; in other cases a resulting prostatic catarrh assists in producing the same abnormal symptoms. A most important (and often undetected) result of gonorrhœa is true spermatorrhœa —the frequent or constant escape of semen without orgasm—probably from relaxation of the ejaculatory ducts.

Morbid conditions affecting other than the genital organs may be prominently manifested by derangements of the sexual function. The salacity of phthisis and of tabes in its early stages, the impaired virility of diabetes and chronic nephritis are familiar examples; the depressing influence upon the sexual functions of dyspepsia and of mental or emotional tension are equally well known. In the last few years I have seen several cases of impaired virility or actual impotence in railway employés, which seemed to be a manifestation of a spinal disorder caused by the constant jarring of the cars; at any rate, treatment which had long failed to relieve while the patient pursued his avocation, was followed by immediate improvement so soon as railway travel was discontinued. In several other instances I have seen an "irritable weakness" of the genital organs, manifested by frequent and premature ejaculation, much improved by abstinence from tobacco.

The *diagnosis* must not rest solely on the symptoms related by the patient; those which he notices and describes—pollutions, impaired virility, etc.—may be due to any one of many causes; and in numerous instances sexual debility is indicated chiefly by derangements of other than the genital organs—stomach, brain, eye, and muscles; an unsuspected spermatorrhœa being the sole symptom furnished by the sexual organs.

Inquiry should always be made as to the *existence of urethral discharges;* if such are found they should not be dismissed as gleet or prostatorrhœa, nor magnified into a seminal flow; the fluid should in every case be submitted to microscopic examination. Doubtless many a slight discharge which follows a gonorrhœa, and is consequently regarded and treated as a gleet, is really a true spermatorrhœa, and constitutes the key to obscure nervous symptoms; while a so-called "prostatorrhœa" frequently proceeds not from the prostate but from the urethral glands. Fürbringer's demonstration that the so-called spermatic crystals of Böttcher are produced solely from the prostatic secretion, constitutes a valuable aid in the differential diagnosis of urethral discharges and hence of genital disorders.

The *examination of the urine* is almost equally important; aside from the possible discovery of disease in the kidney or bladder, the urine may reveal evidences of genital disorders. Such is frequently the significance of persistent *polyuria* with low specific gravity; *oliguria* or even anuria (long known as a symptom in hysterical women); transient *glycosuria* or *albuminuria* is by no means a rare symptom of sexual disorder in the male; more frequently there is observed a persistent *alkalinity* of the urine, with consequent precipitation of the earthy phosphates, or a constant and voluminous sediment of *calcium oxalate* (usually seen in patients who suffer also from nervous dyspepsia). An excess of *indican* is not infrequent in those addicted to masturbation or frequent sexual excitement; Ultzmann has even seen a considerable sediment of indigo in several cases.

Finally, the urinary sediment should alway be examined for *spermatozoa;* for true spermatorrhœa, the semen escaping perhaps only during urination and defecation, is not infrequent in men who have had gonorrhœa, or have for years committed sexual excesses. A thorough search will often reveal it in married men in middle or advanced years who complain of an impairment of virility.

An examination of the semen is sometimes necessary in order to determine the reason for the barrenness of a marriage; the researches of recent years have shown that in about one-fourth of all cases, a failure to propagate must be ascribed to a defect not of the wife but of the husband, who in consequence of gonorrhœa, sexual excesses, or constitutional taint, fails to secrete spermatozoa capable of fertilizing the ovum.

The *treatment* must be directed to the *patient* and not to the symptoms. This cardinal principle in medicine is perhaps in no other class of disorders so neglected as in the treatment of sexual derangements of the male. A routine prescription of the bromides and steel sounds for nocturnal pollutions, for example, is beneficial for the robust, plethoric patient, who suddenly discontinues masturbation or excessive venery, but disastrous to the nervous, feeble individual whose pollutions, like his dyspepsia and nervousness, are mere evidences of general debility; such a patient is benefited by strychnine, quinine, and iron internally, perhaps by galvanism locally, but he requires no bromides nor other depressing agents. In every case the patient should be studied, his physical and mental condition ascertained and taken into account in the treatment. One young man is alarmed by a sediment of urates or phosphates in the urine, or by the appearance of moisture at the meatus after an erection; merely to assure him of the insignificance of these appearances will not prevent him from brooding over the impending "loss of manhood," and similar follies. The reaction of the urine should be corrected so as to prevent the deposit of these sediments; to divert his mind from the subject he should engage in active

physical or mental exercise. Another individual is disturbed by frequent pollutions, which are really only substitutes for frequent voluntary ejaculations, after these—whether produced by onanism or by intercourse—have been suddenly discontinued. In such cases local and general sedatives—sounds and bromides—are required. Other patients complain of feeble erections, premature ejaculations, perhaps actual impotence, all proceeding from general debility or other constitutional causes; the treatment must be directed to these rather than to the sexual organs. The same group of sexual abnormalities may, on the other hand, proceed from excessive use of these organs, while the general health is unimpaired; here strychnine, atropine, ergot, cantharides, and savine internally, and the Faradic current locally, furnish the best results. In every case, therefore, the general condition and history of the patient should be investigated in order to determine to what degree the causes of the abnormal symptoms are localized in the genital apparatus; in other words, to ascertain what and where is the morbid condition which is manifested by pollutions, impotence, etc. The treatment must of course be directed to this condition, and may be largely local in one case and chiefly constitutional in another which presents the same sexual abnormality.

CHAPTER XXII.

SEMINAL INCONTINENCE.

Under this term are included two conditions—pollutions or seminal emissions, and spermatorrhœa. These two abnormal phenomena are usually regarded as intimately associated both in their etiology and clinical history; it is assumed that spermatorrhœa is commonly a sequel to pollutions, dependent upon the same causes and representing the climax of the morbid condition. This is, however, a mistaken conception; while it is true that both pollutions and spermatorrhœa are sometimes observed in the same individual, this coincidence is the exception rather than the rule. The mistaken impressions as to the intimate association of the two conditions has doubtless arisen largely from the failure to distinguish a seminal flow (spermatorrhœa) from other discharges often associated with genital derangements, especially gleet, prostatorrhœa, and the secretion of the urethral glands.

By *pollutions* are designated seminal emissions, accompanied by erections, spasmodic contraction of the ejaculatory muscles, and orgasm; indeed, there may be no abnormal feature exhibited except the absence of the natural emotional and mechanical excitement incident to intercourse. Such pollutions occur usually during sleep.

By *spermatorrhœa*, on the other hand, is designated a seminal discharge (which may be occasional and intermittent, or continuous) *without* erection, spasmodic contraction of the ejaculatory muscles, or sensual imaginations. Such seminal losses occur especially during defecation and urination, though the fluid may escape also at other times.

It is important for purposes both of diagnosis and treatment that the essential independence of these two affections in etiology, pathology, and clinical occurrence, be kept in mind; pollutions may be complicated sooner or later with spermatorrhœa, but more frequently terminate in impotence; while genuine spermatorrhœa may long exist without sensible impairment of the sexual power. The essential pathological distinction between the two is expressed by Trousseau and Ultzmann, who define pollutions as a neurosis manifested in irritability and spasmodic action of the ejaculatory muscles (of the seminal vesicles and urethra); while spermatorrhœa is regarded as a paresis of the ejaculatory ducts. The etiology and clinical history are frequently quite distinct in the two affections; masturbation, pollutions, impotence, with neurasthenia in the one case; gonorrhœa, chronic prostatis, spermatorrhœa, often without impairment of health, in the other.

Nocturnal Pollutions.

A normal seminal emission is preceded by an erection of the penis, which consists in a distention with blood of the vascular channels composing the cavernous and spongy bodies. This distention is accomplished by two factors; first, the relaxation of the unstriped muscular fibres in the cavernous and spongy bodies, whereby a passive dilatation is permitted; and, second, a constriction of the veins through which the blood returns from the penis, which is accomplished by contraction of the bulbo-cavernosus and perhaps the ischio-cavernosus as well. By the contraction of the latter muscle, moreover, the organ is erected.

The nervous influence whereby this muscular action is produced is transmitted from the lumbar cord by the erector nerves which arise (in the dog) from the sacral plexus. That there is an independent centre in the lumbar cord capable of producing an erection was demonstrated by Goltz, who produced erections in dogs at will after separating the lumbar segment from the upper portion of the cord. This centre is excited to action by either peripheral or central nervous influence; electric excitation of the brain and of the cervical cord produced erections in dogs (Eckhard). The brain appears to exercise an inhibitory influence whereby the lumbar centre is ordinarily restrained; thus Goltz found that erections were more readily produced by peripheral irritation after isolating the lumbar from the remaining cord. This inhibitory influence is removed by amorous thoughts or by disease of the upper cord whereby transmission from the brain is impeded (as in tabes); such conditions, therefore, favor erections. On the other hand the cerebral inhibition is increased and erection prevented by depressing emotions, as illustrated in psychical impotence.

The lumbar centre may be also excited to increased activity by peripheral irritation; this normally consists in pressure and friction of the glans, re-enforced by congestion of the prostatic urethra and seminal vesicles. The sensations peculiar to the venereal act probably originate in a congestion of the prostatic urethra and distention of the seminal ducts, since the subjective phenomena are experienced undiminished and unchanged after amputation of the penis.

Seminal ejaculation is produced by a spasmodic contraction of organic muscular fibres in the seminal vesicles, the prostate and the urethra, assisted by the bulbo- and ischio-cavernosus muscles. The nervous mechanism requisite to ejaculation appears to be identical with that concerned in simple erection; ejaculation is produced only when the nervous influence proceeding from the lumbar centre has attained a certain intensity. This degree of intensity is naturally attained in the normal animal only by a combination of psychical influence whereby the lumbar centre is relieved from the customary inhibition, with extreme peripheral excitation; in abnormal states ejaculations, like erections, may be retarded by psychical influence, by disease of the upper cord, or by obtunded sensibility of the glans and prostatic urethra; they may be facilitated, on the other hand, and therefore occur upon less than the usual provocation, by certain conditions of the brain and cord, or by increased sensibility of the glans and prostatic urethra.

The natural performance of the sexual act requires, therefore, increased activity of the genital centre in the lumbar cord, which is induced by peripheral excitation (friction) and by the removal of the usual inhibitory influence of the brain (through sight or touch of the female, amorous

thoughts, etc.) and which produces first distention of the penis and finally spasmodic contractions of the ejaculatory muscles. This normal cycle of events can be disturbed or prevented in various ways; the activity of the spinal centre may fail to attain the intensity requisite for ejaculation or even for erection in consequence of (1) organic disease or simple exhaustion from frequent excitement; (2) excessive cerebral inhibition; (3) deficient excitability of peripheral nerves; (4) atony of the muscles required for the act. Conversely, undue activity of the spinal centre resulting in erection and emission upon abnormally slight provocation, is produced by (1) disease or injury to the lumbar cord; (2) deficient cerebral inhibition resulting either from sexual excitement, disease of the brain, or injury of the upper cord isolating the genital centre from the brain; (3) increased excitability of the peripheral nerves.

Clinical illustrations of these different departures from the normal condition are numerous. The effect of cerebral influence in preventing erection or ejaculation is seen in those cases of psychical impotence in which erection fails or subsides before emission occurs; its effect in precipitating ejaculation is seen in the familiar fact that emissions occur early in conditions of great sexual excitement. Tabes dorsalis, while limited to the upper cord, usually induces frequent erections, premature ejaculations, and even nocturnal pollutions, because the inhibitory influence of the brain is arrested; when the disease involves the lumbar cord also the genital centre is disorganized, erections become feeble and finally cease.

I have seen several instances in which both erection and ejaculation were retarded and finally ceased altogether in railway employés, apparently in consequence of an effect produced upon the lumbar cord by the constant jarring of the cars; at any rate the genital functions were restored to their normal state by a change of occupation for a few weeks. Constant congestion of the lumbar cord, on the other hand, provokes frequent erections and emissions; this was well illustrated in a case observed by Fürbringer where, after an injury to the dorsal spine causing complete paraplegia, priapism with almost continuous discharge of semen occurred without the patient's knowledge. That morbid peripheral irritation provokes ejaculation is seen in the cases in which seminal emissions have ceased after the removal of a tight phimosis, division of a contracting meatus, etc.; in Genaudet's case obstinate pollutions were cured by the (accidental) removal of a polyp from the prostatic urethra. On the other hand, a failure to ejaculate may be due to obtunded sensibility of the peripheral filaments; in a case reported by Curling, in which no emissions occurred during intercourse, ejaculation was secured by the repeated application of acetum cantharidis to the glans; and impotence due to anæsthesia of the prostatic urethra has been repeatedly cured by the application of silver-nitrate to this portion of the canal.

Pollutions, therefore, are like other so-called functional disorders of the genital organs—spermatorrhœa and impotence—a *symptom*, the cause for which may be sought in either central or peripheral abnormalities. The prevalent routine practice of regarding involuntary emissions as infallible evidence of masturbation, confessed or unconfessed, is responsible for many cases of failure in treatment.

Nocturnal pollutions are physiological phenomena in a continent individual; doubtless many a boy has been unnecessarily treated for this symptom of health. If the patient acknowledges previous masturbation, no matter how slight, few physicians can resist the temptation to regard the nocturnal emissions as evidence of a morbid condition produced by this

habit; and the patient's previous anxiety and distress may be so aggravated by the doctor's confirmation of his fears, that the pollutions are subsequently increased in frequency and his general health deteriorated.

The frequency with which physiological pollutions may and do occur varies extremely with the temperament and habits of the individual. It is generally stated that a healthy man should have a nocturnal emission not oftener than once in ten to fourteen days; yet a careful inquiry shows that pollutions occur in some robust, full-blooded men one, two, or even three times per week year after year, without appreciable impairment of the general health or genital function. Pollutions are regarded as pathological when they are followed by lassitude, mental depression, pain in the loins and back of the head, or other evidences of nervous exhaustion; and when they occur without dreams, erections, or orgasm and are discovered only by the stains on the linen. This is doubtless the only possible rule to adopt in deciding upon a line of demarcation between physiological and pathological frequency of emissions; yet care should be taken not to ascribe to the pollutions themselves the evidences of nervous exhaustion which are really due to the patient's morbid anxiety regarding his condition or to general debility and exhaustion. The guilty consciousness of masturbation or previous gonorrhœa is readily aggravated by quack advertisements and sometimes by a physician's mistaken diagnosis, into a mild neurasthenia which is ascribed directly to the pollutions. So long as every emission is accompanied by amorous dreams, orgasm, and complete erection, the physician should be cautious in magnifying the ill effects, and should seek to distinguish the purely psychical depression and morbid fancies from the symptoms which can be legitimately ascribed to pollutions. Moreover, emissions may be merely and entirely a *result* of nervous exhaustion which is manifested also by dyspepsia, mental lethargy, etc.—symptoms usually ascribed to the coincident pollutions, if these exist.

In rare cases seminal emissions occur during the waking hours; they are usually accompanied with an erection and lascivious thoughts, and are excited by mechanical irritation of the genitals (rubbing against the clothing) or by purely mental influences (perusal of libidinous books or newspaper items). It is but seldom that ejaculation occurs, whether the patient be asleep or awake, without erection and sexual thoughts.

Nocturnal pollutions constitute one of the symptoms of numerous conditions which can be grouped as follows:

1. *General neurasthenia* from any cause; this is often associated with anæmia and debility, constituting the "irritable weakness" of the older writers. The cause may be found in some defect of nutrition or mental depressing influence independent of the sexual organs; Trousseau called attention to the frequency of nocturnal pollutions in patients of this class who had in earlier life suffered from nocturnal incontinence of urine. These patients are especially prone to various neuroses including epilepsy and insanity, whence has arisen the prevalent idea that pollutions cause these nervous affections. If the patient has at any time masturbated (and comparatively few boys have not), he is thoroughly convinced that all his ills originated in this habit; and his opinion is unfortunately often shared by his physician, who accordingly concentrates his attention and therapeutic efforts upon the prostatic urethra. Such cases are usually better without local treatment; the pollutions are merely one result of a constitutional condition, and can be relieved only by measures which improve this condition. If the patient can be convinced of this relation and can

thus divert his attention from the pollutions, a long step toward recovery, both local and general, is often made.

2. *Sexual excesses*—in natural or unnatural ways—are doubtless responsible for nocturnal pollutions in the majority of cases. Foremost among these as to frequency is masturbation ; next the ungratified sexual excitement produced by reading lascivious articles, cheap love stories, toying with females, etc. ; these practices, so common among the youth of large cities especially, certainly play an important rôle in the production of sexual derangements of both sexes. In comparatively few cases, usually married men, pollutions must be charged to excesses in sexual intercourse, particularly when this is performed in unnatural ways—with premature withdrawal, or condoms.

The excessive use of the genital organs favors nocturnal pollutions, not because of the seminal losses thereby incurred, but by the effects produced upon the peripheral nerves of the genital apparatus, the spinal cord, and the brain. Every orgasm is preceded and accompanied by hyperæmia of the nervous centres concerned in the sexual act ; frequent repetitions of this congestion produce a hyperæsthesia ("irritability") of these centres, which therefore respond with an ejaculation to slight provocation. This increased reflex activity of the nervous centre is accompanied by a hyperæsthesia of the peripheral nervous structures located in the glans penis, the prostate, and the seminal vesicles ; hence erection and ejaculation occur in response to a provocation which is insufficient to excite such activity in the normal condition of the organs.

While such irritability of the genital nervous apparatus can undoubtedly be produced by masturbation, the disastrous effects of this practice have been in former years and are still by many physicians greatly exaggerated. For comparatively few men can truthfully say that they have never at any time performed this act ; and if such a confession can be wrung from a patient complaining of sexual disorders, the physician is prone to recognize in this self-pollution the cause of the ills complained of. Such a course has certainly many advantages : it affords an easy and tangible diagnosis ; it accords with the despondent patient's convictions ; and palliates to some extent a possible failure in treatment, by throwing the responsibility upon the guilty patient. The promiscuous ascription of nocturnal pollutions, spermatorrhœa, impotence, etc., to early masturbation, is unjustifiable ; it proves clearly how little attention and scientific investigation this subject has received. The good sense of the profession has discarded the astounding statements of the older writers and modern advertising charlatans, that self-pollution is directly productive of consumption, insanity, and death ; yet this habit is still generally credited with greater morbid tendencies than the facts warrant. Careful inquiry may show that there exists a more direct and immediate cause for a given sexual disorder than a habit of onanism discontinued possibly years before the development of the complaint. Some of these immediate causes can be, it is true, traced to previous masturbation ; such are the strictures of large calibre that are frequently found in confirmed onanists ; but the important fact remains that a confession of previous masturbation is not to be accepted as a final diagnosis and does not diminish the necessity for a careful examination of the patient's sexual organs and general condition. It is further to be remembered that masturbation may be itself a symptom produced by local irritation—phimosis, contracted meatus, vesical calculus—or by a neurotic disposition. A confession of the habit should therefore be followed by physical examination as well as moral sympathy and exhortation.

It is impossible to say how much indulgence in this habit is necessary for the origination of sexual disorders; the amount naturally varies with the temperament and health of the individual as well as with his mental and physical tastes and occupations. It is to my mind doubtful whether a healthy boy who continues active physical and mental exercise, and who begins the habit not because of any local irritation or neurotic tendency, but because initiated therein by older companions (the usual way), ever injures his health seriously and permanently by masturbation. The prevalent ideas as to the destructive physical effects of the habit are derived from those cases in which the results of neurotic tendencies and the mental distress occasioned by a guilty and fearful conscience are ascribed directly to the habit in question. I am aware that the opinion just expressed is opposed to the general teaching and belief of writers upon this subject; yet it is an opinion based upon careful and somewhat extensive inquiries among young men. Sir James Paget expresses the opinion that "masturbation does neither more nor less harm than sexual intercourse practised with the same frequency in the same conditions of general health, and age, and circumstances;" it may be doubted whether it does as much harm, since the excitement (the injurious factor) is generally less during masturbation than in natural intercourse. Yet because self-pollution can be practised more frequently than intercourse, and especially because it is performed at an age when both body and mind are undeveloped and susceptible to morbid impressions, the habit undoubtedly produces ill effects far more frequently than the natural act.

It is therefore not denied that masturbation may be injurious either as direct cause or important factor in the development of certain spinal affections, such as myelitis, chronic meningitis, spinal irritation, and neurasthenia, as declared by Erb, Rosenthal, and Hammond among others. I would merely protest against the somewhat prevalent habit of regarding onanism as the source of all those functional disturbances of brain, cord, and genital organs, for which no other cause is apparent; and I would express the conviction that this loathsome habit is held responsible for many evils of which it is merely a symptom and often a result.

3. *Local inflammations in the genital organs*, especially chronic prostatitis resulting from gonorrhœa, are frequently responsible for nocturnal emissions. This sequel occurs especially when the patient is of neurotic temperament or has been addicted to masturbation; yet gonorrhœa alone is a sufficient cause for pollutions. A more frequent result, it is true, is genuine spermatorrhœa, that condition in which seminal losses occur without orgasm or ejaculation and merely in consequence of dilatation and paresis of the ejaculatory ducts. Other local irritations in or near the genital organs may also be productive of pollutions; among these are strictures, including those of large calibre which escape detection by the ordinary means of exploration; catarrh of the seminal vesicles (which in its chronic form is a not infrequent sequel of gonorrhœa); balanitis, phimosis, urethral polyps, vesical calculi, fissures of the anus, hemorrhoids, etc. These distant irritations probably provoke pollutions only when there already exists a predisposing influence, such as chronic prostatitis or hyperæmia of the genital apparatus from sexual excesses. Various other local irritations have occasionally seemed to induce emissions in individuals whose genital apparatus has been rendered irritable by previous gonorrhœa or masturbation; among these are herpes of the glans and prepuce, congenital or acquired contraction of the meatus, shortness of the frenum, spasmodic stricture, epididymitis, cauterization of internal hemorrhoids, and

habitual constipation; the influence of the latter is simply its tendency to maintain constant venous congestion of the prostatic plexus.

4. *Certain constitutional diseases* are accompanied with pollutions; these are phthisis in its early stages, diabetes, and acute febrile diseases, especially typhoid fever and variola, during convalescence. The emissions may continue for weeks after recovery from the disease.

5. *Organic disease of the spinal cord* sometimes causes pollutions, presumably because, as in Goltz's experiment, the genital centre in the lumbar cord is relieved from the normal inhibitory influence of the brain; this phenomenon has been seen especially in tabes dorsalis, bulbar paralysis, and injuries to the cord. The symptoms of these affections must of course be distinguished from the evidences of spinal irritation and neurasthenia, which are often found in the subjects of pollutions.

Habitual seminal losses have occasionally dated from some intense emotion, such as fright. While this is doubtless sufficient to produce involuntary spasmodic action of the genital as well as the urinary and rectal muscles, it may be doubted whether it can produce habitual seminal incontinence in an individual who is not predisposed thereto by other influences. Before attributing pollutions to such emotions, or to excessive mental exercise and sexual continence (Lallemand), it should be ascertained that the patient is not seeking to conceal under these pretexts the results of masturbation.

Clinical History.—The symptoms presented by the subject of abnormal pollutions vary extremely with the degree of incontinence, the habits and occupations of the patient, and especially with his temperament and previous physical condition. The symptoms may be manifested chiefly or exclusively by the genital apparatus; the general health remaining unimpaired; or they may be exhibited as derangements of the brain, spinal cord (spinal irritation), circulatory and digestive organs, while the genital functions are not conspicuously disturbed. In general it may be stated that prominent local symptoms—derangements of the sexual function without neurasthenia—are found usually in those individuals who have habitually enjoyed vigorous and sturdy health; while in nervous, weak, or cachectic patients the sexual derangement may be masked by more prominent disturbances in other organs. The true source of the difficulty may hence be overlooked; the patient may even fail to mention his pollutions or decreased sexual vigor, either because he really attaches but little importance to them, or because he hopes to avoid the humiliating confessions thereby entailed and yet secure relief. He frequently complains of irritability or "weakness" of the bladder, dribbling of urine or "kidney trouble."

The most diverse combinations of symptoms are observed, determined in part by the patient's individuality; there is therefore no uniformity in the clinical picture. In general the first symptoms manifested are pain in the back and head, lassitude, mental depression, and indisposition to exertion; these signs are observed especially on the morning after a pollution has occurred. After a time voluntary erections become less frequent and incomplete; ejaculation occurs too early during intercourse; and finally complete impotence may result. Meanwhile pollutions have become more frequent, perhaps occur during the day, and are no longer accompanied by erotic dreams or orgasm: true spermatorrhœa occasionally appears. The genital organs themselves may exhibit no anomaly; diminished sensibility of the scrotum, softness of the testicle, coldness of the penis, are by no means constant symptoms; upon the introduction of the sound, the urethra is found hypersensitive except in the later stages, when anæsthesia may exist.

The semen may present only normal features ; or there may be found also numerous leucocytes and cylindrical epithelial cells—the products of catarrh of the prostate. When the seminal vesicles also are involved in the chronic catarrhal process, the yellowish, gelatinous, sago-like balls, normally produced in these vesicles, are found in great abundance, though they are soon dissolved. Large hyaline cylinders, often studded with round epithelial cells, are a frequent feature ; these are derived probably from the prostatic follicles (according to Nepveu from the testicle). The spermatic crystals are seen early and in great abundance.

At a later stage the semen presents abnormal characteristics : the viscid secretion of the testicle is diminished, causing a diminution in the consistence and opacity of the semen, which is therefore more watery, transparent, and rapidly deposits a sediment. The spermatozoa are less numerous, their movements less active and of shorter duration ; their activity cannot as in health be restored by alkaline solutions. When the pollutions have become excessive, spermatozoa may be absent entirely ; if present, they are few in number, incompletely formed, and motionless or moving feebly ; cells from the testes containing partly developed spermatozoa are also seen.

Finally the semen contains but little of the products of the testes ; it is merely a mixture of the secretion from the seminal vesicles, prostate, and urethral glands ; it is in this state of the affection that true spermatorrhœa (without ejaculation or orgasm) often occurs, and because no spermatozoa are seen this discharge may be incorrectly regarded as prostatorrhœa. The distinction between the two is indeed often impossible except by means of the history and by examination of the semen obtained by ejaculation.

The urine may be normal, aside from the catarrhal prostatic products and occasional spermatozoa which it contains. It is often neutral or alkaline, and turbid from excess of phosphates ; it frequently contains a trace of albumen, and occasionally a little sugar ; an excess of indican is not unusual. Numerous calcium oxalate crystals have been regarded as characteristic of the affection ; but such crystals are usually found in the urine of dyspeptic and nervous subjects, even when free from sexual abnormality ; polyuria is also observed.

The local may be overshadowed by the general symptoms ; yet in a certain by no means small percentage of cases the general health is unaffected even when pollutions have occurred with undue frequency for years.

The morbid symptoms are manifested as nervous and (secondary) nutritive derangements. Among the former are lassitude, absence of mental and physical energy, and mental depression ; the latter is traceable to the patient's anxiety as to his health and virility rather than to the direct effects of the pollutions. In some cases this depression, amounting even to hypochrondria or hysteria, is almost the only symptom aside from the genital derangement ; the individual broods over his "lost manhood ;" is filled with remorse and regret for his evil practices ; becomes peevish, morose, and melancholy ; and torments his physician with frequent letters and visits in which the gloominess of his wrecked life are pitifully portrayed. Insomnia is a regular feature ; the patient complains of numerous local nervous disturbances ; dizziness, weakness, hot and cold sensations, formication, numbness, weakness, muscular pains, deafness, photophobia, etc. ; it is often difficult to decide which of these symptoms are really experienced and which imagined. Among the objective symptoms are coldness

of the hands and feet, clamminess of the skin, emaciation, pallor, irregular action of the heart, dyspepsia, and constipation. If the patient conceal or deny sexual excesses and seminal incontinence, he may be incorrectly regarded as the subject of serious organic disease of the stomach, heart, or brain. That organic disease of the cord is observed in those who have been addicted to masturbation and have suffered from pollutions, is undoubted; but that there is a definite relation of cause and effect between the two conditions remains to be proven.

The *diagnosis* rests of course largely upon the patient's statements; and it is to be remembered that these statements are sometimes false; for it occasionally happens that a masturbator, ashamed to confess the habit, and yet conscious of the necessity for treatment, hopes to secure the needed assistance by professing to be subject to pollutions. Such individuals often betray themselves by a peculiar embarrassment, and can usually be made to confess through the exercise of tact on the part of the physician.

The *prognosis*, while generally favorable, is dependent largely upon the etiology, the age, temperament, and physical condition of the patient, as well as the duration and stage of the affection. Pollutions caused by chronic prostatitis after gonorrhœa, rarely resist proper treatment; when induced by masturbation, the affection is less tractable, though a cessation of the practice is sometimes followed by a spontaneous arrest of the abnormal pollutions. Even when impotence and marked neurasthenia have been developed, the prognosis is often favorable. If the patient has long practised masturbation, and from an early age, if he is of a decidedly nervous temperament, and especially if he has developed hypochondria, the outlook is less favorable. Pollutions during the waking hours, or at night without erection and orgasm, mark a serious phase of the affection. Most obstinate, and often incurable, are the cases in which the seminal vesicles are the seat of chronic inflammation.

Treatment.—Prophylaxis consists in the avoidance of undue sexual excitement, whether as onanism, venereal indulgence, unnatural intercourse, toying with females, or erotic fancies. These practices should of course be discontinued, yet the physician's efforts to secure this result are not always successful. The various mechanical devices—toothed rings for the penis, Trousseau's "prostatic compressor," etc.—are useless in preventing pollutions.

The line of treatment must be determined by the etiology of the affection. The general fact is to be borne in mind that pollutions prove the existence of over-excitability in some portion of the nervous mechanism of the genital apparatus. The first step in treatment is therefore to locate this irritability; it may be (and usually is) found in the peripheral nerves, as hyperæsthesia of the prostatic urethra, of the seminal vesicles, or of the glans penis; it may comprise also an undue reflex activity of the genital centre in the lumbar cord; and this in turn may be the result of excessive use of the genital organs, of disease in the lumbar cord, of interference with the inhibitory influence of the brain through disease or injury of the upper cord, or finally, of some nutritive disturbance (phthisis, diabetes), neurotic tendency, or general debility. Two or more of these factors may coexist in the same individual; hence in every case the general condition, temperament, and habits of the patient, as well as the sexual apparatus should be investigated. Even when protracted masturbation is confessed, and hyperæsthesia of the prostatic urethra discovered, the possibility that other predisposing influences exist must not be forgotten.

The external genitals, the anus, rectum, and seminal vesicles should be examined; a phimosis, redundant prepuce, contracted meatus, should be noted and subsequently treated if other measures fail. Strict cleanliness of the glans penis must be observed, sometimes possible only after the removal of a long prepuce; hemorrhoids or other rectal affections must be removed; it may be necessary to divide a short frenum. Pruritus should be relieved by cleanliness and the use of corrosive sublimate (two or three grains to half an ounce each of water and glycerine); herpes or eczema of the genitals or perineum, should be removed; a varicocele should be suspended or otherwise relieved; a urethral stricture, even when of large calibre, should be divided, or at least palliated by dilatation. In short, every possible source of irritation should be sought, and, so far as may be, removed. Habitual constipation must be avoided; for this purpose salines (Hunyadi water) may be employed, or if atony of the bowels exist, a pill containing one-third of a grain of extract of nux vomica and one-fourth of a grain each of extract of belladonna and aloin may be taken before retiring.

The diet must be nutritious but not irritating; liquors and strong coffee should be avoided or taken sparingly; food may be taken at short intervals and in small quantities, but little being eaten in the evening; both rectum and bladder should be evacuated shortly before retiring. The bed should be hard and the covering light; the patient should be awakened early, and immediately evacuate the bladder. Active physical and mental exercise are extremely valuable remedies, in the absence of neurasthenia; the patient's attention and energies can be by hard work and mental preoccupation diverted from the genital apparatus; if the physical condition forbid active effort, a change of residence and occupation may effect the same result. Travelling for pleasure often aggravates the condition by affording ample time for despondency.

Medicines must be addressed to the patient, not to the pollutions. Tonics are indicated only when debility and anæmia exist; the indiscriminate use of strychnine, phosphorus, cantharides, damiana, etc., is useless or harmful. So long as erections and ejaculations are perfect, the remedies required are such as diminish the excitability of both peripheral and central nervous structures; and for this purpose nothing equals the bromide of potassium. One to two drachms of this should be given in the course of twenty-four hours, the largest dose just before retiring; if it seem to cause depressing effects it may be combined with digitalis or quinine, or replaced by chloral. This alone, combined with attention to hygiene, often suffices to diminish materially the number of pollutions: nothing further may be required in treating young, robust men who have three, four, or five emissions weekly after abandoning the practice of onanism. The pollutions in these cases often indicate merely a rapid production of semen which must find exit, and is hence discharged involuntarily when self-pollutions cease. Sometimes it becomes necessary to employ local sedatives, also warm hip-baths at night, and the daily passage of a sound.

If erections are feeble and transient, and ejaculation premature, strychnine and cantharides should be given, the former in large, the latter in small doses (two or three minims of the tincture three times daily). Atropia and ergot are also to be tried if the former fail. In some of these cases, in which the sexual derangement seems to be largely an expression of general debility, I have seen great benefit follow the use of the standard prescription for certain forms of amenorrhœa—iron, savine, and aloes.

The *local treatment* is determined by the condition of the prostatic urethra; in nearly all cases of nocturnal pollutions without spermatorrhœa, this region (as well as other parts of the urethra) is hyperæsthetic; the treatment therefore is such as will obtund this over-sensibility. The most valuable agent for this purpose is the steel sound; the largest sound which can conveniently enter the meatus should be introduced daily, and allowed to remain from five to twenty minutes, the time being gradually increased; or the cooling sound of Winternitz may be used instead. Warm hip-baths are also advisable. Occasionally these measures are insufficient; in this case the needed impression upon the prostatic urethra can probably be made by nitrate of silver. Lallemand's plan—the application of the solid caustic—though often successful, is dangerous; it has produced not only local inflammation but even cysto-nephritis, pyæmia, and uræmia (Rose). A safer method consists in the application to the prostatic urethra, by means of a porte-remède, of small cocoa butter suppositories, each of which contains one-sixth to one-eighth of a grain of silver-nitrate. This usually occasions some smarting and vesical tenesmus for an hour or two, during which the patient should retain the recumbent posture; this application may be repeated in three or four days.

In a certain number of cases benefit is derived from galvanism; the anode is applied to the lumbar region, while the cathode is moved over the perineum and the penis. The current should be at first not stronger than can be comfortably passed through the operator's temples, and the sitting limited to three or four minutes daily; both the strength of the current and the duration of the sitting may be gradually increased; the patient should at no time suffer pain from the application.

It sometimes happens that after the urethral hyperæsthesia is subdued and the nocturnal pollutions correspondingly decreased in frequency, true spermatorrhœa remains; this condition calls for somewhat different measures, to be mentioned in the next section.

Spermatorrhœa.

This affection, consisting in the involuntary loss of semen without orgasm or ejaculation, is generally regarded merely as the last stage of nocturnal pollutions; hence it is described as a feature of the latter affection, and its occurrence is said to mark a case as serious, rendering the prognosis doubtful; though it is by no means true that it appears only in advanced stages, or constitutes a deplorable feature of the case.

Now it cannot be doubted that spermatorrhœa is sometimes superadded to pollutions, and that it can be produced by the same causes; yet it occurs also in individuals who do not suffer from excessive pollutions; indeed a careful examination will sometimes reveal it where no seminal incontinence is suspected by the patient and no constitutional symptoms manifested; it is met unexpectedly in cases where the subject complains of declining desire and power; and even more frequently found where no decline in virility has been noticed, treatment being requested for some disease, real or supposed, of the urethra or bladder.

The spermatorrhœa which follows pollutions may be produced by any of the causes of the latter affection, especially masturbation; in those cases, however, in which it appears without previous abnormal pollutions, it is usually the result of gonorrhœa. Under such circumstances the real nature of the slight discharge which may be present is not discovered; for

it cannot be recognized without the microscope, which is, unfortunately, seldom employed in the examination of urethral discharges. The case is regarded as one of gleet or prostatorrhœa; the latter is in my experience less frequent than a true spermatorrhœa.

Clinical History.—Spermatorrhœa is but a symptom; hence the history of the patient varies extremely. When it occurs as a complication of pollutions, it is accompanied with the symptoms found in the latter affection, and in nowise aggravates the patient's general condition, unless indeed indirectly by increasing his mental depression.

When it arises independently of pollutions (usually as a sequel to gonorrhœa) it is seen in the most diverse conditions. The seminal loss itself occasions no drain upon the patient's strength, since it is not accompanied with the intense excitement which constitutes the injurious feature of frequent ejaculations. If free from other complaints, the patient may therefore enjoy the most vigorous health; the only constitutional symptoms observed are caused indirectly by the mental depression and gloomy forebodings aroused by the knowledge of seminal losses or by a diminution in virility. The latter is a frequent accompaniment of spermatorrhœa; erections occur less frequently and promptly; ejaculation is retarded; intercourse is less pleasurable; sexual desire is diminished, and finally impotence occurs.

The seminal loss occurs either as a constant, slight discharge or merely in connection with acts of defecation and urination. In the former case the discharge may be so slight as to merely moisten the lips of the meatus, which are often agglutinated; or it may be sufficient to stain the linen. In either case the quantity expelled is increased during defecation, probably not by pressure of the fæces upon the seminal vesicles (since these are so located as to escape such pressure), but by contraction of these vesicles coincident with that of the rectum; perhaps the abdominal pressure, so exerted as to force the contents of the pelvis toward the perineum, may assist in evacuating the vesicles (Fürbringer). The urine contains a flocculent sediment which is found upon examination to consist of semen; the amount of this ingredient may be indeed so great as to give the urine a chylous appearance (Eichhorst).

Diagnosis.—Spermatorrhœa can be positively recognized only by microscopic examination of the discharge. The appearances presented by the seminal fluid vary in different stages; so long as spermatozoa are found in the *spontaneous* discharge, not once simply, but upon repeated examinations and in considerable numbers, the diagnosis is easy; the fluid which appears at the meatus at stool or after digital pressure of the prostate, contains a greater number of spermatozoa, but the discharge thus obtained should never be alone relied upon for a diagnosis; since if the seminal vesicles of a healthy person happen to be distended with semen, spermatozoa are often expelled into the urethra by straining at stool. In chronic prostatitis, too, a few spermatozoa are occasionally found even in the spontaneous discharge; if many of these cells be present upon repeated examinations, it is evident that the inflammation is not limited to the prostate, but involves the seminal vesicles as well, or that the ejaculatory ducts are relaxed; in either case true spermatorrhœa exists.

The seminal discharge must be distinguished by the microscope from gleet, prostatorrhœa, and urethrorrhœa. This is not difficult so long as spermatozoa are found in considerable numbers; in their absence—which may be temporary or permanent (azoöspermatorrhœa)—there is still no difficulty in excluding gleet and urethrorrhœa; for in neither of these conditions do we find the spermatic crystals, the prostatic epithelium and con-

cretions which are present when the discharge proceeds from the seminal vesicles and therefore receives a contribution from the prostate. It is a mistake to suppose that a differential diagnosis can be regularly made without the microscope; a gleety discharge may be purulent or almost watery; but seminal fluid may exhibit precisely the same macroscopic features, its viscidity and turbidity varying with the proportion of semen and prostatic secretion present in the mixture. A seminal discharge may indeed simulate closely the clear, transparent, and viscid fluid which proceeds from the urethral glands (usually described as prostatorrhœa).

The distinction from true prostatorrhœa may be extremely difficult; for in the absence of spermatozoa, the characteristic features of semen are furnished by the prostate, and may hence be exhibited by prostatorrhœa. The presence of hyaline, sago-like bodies in considerable number indicates an admixture of fluid from the seminal vesicles; the rapid and extensive formation of the so-called spermatic crystals is not characteristic of spermatorrhœa, since it seems to depend upon the absence of spermatozoa whose movements prevent crystallization; this rapid formation is observed in simple prostatorrhœa. A distinction between the two can sometimes be made by an examination of the prostate; if this organ be found normal, and if the discharge contain no evidences of prostatic inflammation (casts of the follicles) spermatorrhœa may be affirmed, even in the absence of spermatozoa. Indeed in every case, an examination of the prostate and exploration of the urethra should be made.

The importance of a correct diagnosis in cases of urethral discharge cannot be overestimated; much of the disrepute which attaches to the treatment of spermatorrhœa is due to faulty diagnosis. This has been impressed upon me by ample personal experience, of which the following case may serve as an illustration: A commercial traveller, twenty-seven years of age, unmarried, sought advice for the relief of spermatorrhœa, from which he had suffered for more than two years. He had been addicted to masturbation until about twenty-one years of age, and confessed to having practised the vice occasionally ever since; for several years he had had nocturnal pollutions from one to four times each week. Ejaculation during intercourse was usually precipitate. Five years previously he had acquired gonorrhœa and had had a second attack two years later; the spermatorrhœa was first noticed some months after the latter attack. The flow had been at first intermittent, observed chiefly in the morning and after defecation; in time it became almost continuous though never excessive; the meatus was constantly moist and a few drops of a turbid or nearly clear liquid could be pressed from the urethra. The patient's general appearance suggested the dismal pictures of Lallemand; he was thin, pale, listless, despondent, and tremulous. For nearly eighteen months he had been unsuccessfully treated in various ways—atropine and tonics internally, sounds, electricity, and silver-nitrate locally; and he was verging on the deepest melancholy.

Upon examining the discharge it became apparent that it contained no semen; neither spermatozoa nor prostatic ingredients were found. The history of gonorrhœa naturally suggested the possibility of gleet; the urethra was extremely sensitive at several points as well as in the prostatic portion, and two strictures, calibre 21 and 27 respectively, were found, the former half an inch, the latter five inches from the meatus. Dilatation produced no effect upon the discharge; the strictures were resilient. Dilating urethrotomy was then performed and a No. 34 sound passed daily until the wounds had healed; the discharge ceased entirely.

The effect upon the patient's condition was surprising; the cessation of the discharge and the proof that it had never been spermatorrhœa anyhow, produced a revulsion of feeling which was soon exhibited in improved nutrition. Although the nocturnal pollutions continued with undue frequency, the general health, mental and physical, was practically restored. By further treatment the pollutions were somewhat reduced in frequency, after which the patient passed out of my sight.

A mistaken diagnosis which is probably more frequent is the converse of that illustrated in this case—namely, to regard a true spermatorrhœa as gleet. When it is remembered that the etiology of both is a previous gonorrhœa and that spermatorrhœa frequently occurs (contrary to the general impression) without previous excessive pollutions, and that both discharges may be macroscopically identical, such a mistake seems plausible. As already stated, many cases occur in which the microscope only can distinguish a gleet from spermatorrhœa and prostatorrhœa. In the absence of pronounced stricture and granular patches in the urethra, the possibility that a supposed gleet may be really spermatorrhœa should not be forgotten.

Prognosis.—This varies with the age and constitution of the patient, and with the duration and cause of the discharge. The affection is usually obstinate, especially in those cases in which it has originated in a gonorrhœa (the usual cause). As a feature associated with nocturnal pollutions, spermatorrhœa is less obstinate. The probabilities of recovery diminish of course with the duration of the affection and with the degree of associated mental depression and nervous symptoms. On the other hand, spermatorrhœa (without abnormal nocturnal pollutions) frequently exerts no injurious effects upon the constitution; as already stated, it may exist for years undiscovered and unsuspected, and be detected accidentally. Even the genital function is often maintained in its normal vigor; the patient remains potent and fertile.

Treatment.—This is determined by the cause, and by the condition of the prostatic urethra.

So long as nocturnal pollutions constitute a prominent feature, the treatment required will be that already indicated. In those cases in which pollutions are infrequent, as well as in those in which the spermatorrhœa has resulted not from masturbation but from gonorrhœa (and in such nocturnal pollutions are often absent), the sensibility of the prostatic urethra is usually obtunded, and the passage of the sound occasions no pain. Here there is ofter atony and relaxation of the ejaculatory ducts and probably of the seminal vesicles as well. The treatment therefore consists in an attempt to relieve this atonic condition.

This object can be attained by a combination of general and local remedial measures. The former consists of tonics, active exercise, amusement; such cases have sometimes been cured by an enjoyable vacation. The remedies to be addressed to the local condition are iron, strychnine, ergot, and cantharides; the iron is useful even in those cases in which general anæmia does not exist. It is in these cases that Lallemand's procedure—cauterization of the prostatic urethra—celebrated its greatest triumphs; and the less objectionable substitutes already described—cocoa-butter bougies containing one-tenth to one-eighth of a grain of silver-nitrate—are certainly useful. Steel sounds afford but little benefit; cold hip-baths and the injection of cold water into the rectum or against the perineum are useful; and robust cases profit by sea-bathing.

The use of the Faradic current, while wholly unreliable and often use-

case has nevertheless produced most gratifying results in individual cases even after the failure of the usual remedies, and should never be omitted in treating an obstinate case. The positive pole is placed upon the perineum, the negative in the rectum or the urethra; the dangers of the latter method have been already indicated. The current must be at first imperceptible to the patient and the sitting not more than two or three minutes; the strength and duration of the application are to be gradually increased in successive daily sittings. If this method produces no perceptible effect in fifteen or twenty sittings, it may be abandoned as useless.

The subject of spermatorrhœa should be permitted a very moderate amount of sexual indulgence; absolute continence is required only in cases of decided sexual exhaustion. Even after recovery there is an unfortunate tendency to recurrence, to avoid which the patient should be warned of the necessity for avoiding sexual excesses of any kind.

CHAPTER XXIII.

IMPOTENCE AND STERILITY.

Fecundation of the ovum requires on the part of the male the deposit in the vagina of normal spermatozoa. Sterility of the male may therefore be due to a failure to copulate (impotence), failure to ejaculate (aspermatism), or the absence of fertilizing spermatozoa from the semen (azoöspermism); any two or all three of these conditions may of course coexist in the same individual.

The term *impotence* is technically restricted to the inability to perform the sexual act. It is a frequent disorder and may be dependent upon any one of several morbid conditions:

1. Diminished reflex excitability of the genital centre in the lumbar cord, or decreased sensibility of the peripheral nerves.

2. Overexcitability of the same centre and irritability of the peripheral filaments.

3. Congenital or acquired defects of the genital organs.

1. The normal performance of the sexual act begins with erection, which is accomplished through the influence of mental impressions whereby the inhibitory action of the brain upon the genital centre is diminished; the continuance of this mental influence, reinforced by mechanical excitation of peripheral nerves in the glans, augments the activity of the genital centre until ejaculation is produced, whereby the act is completed; the erection then ceases. It is evident, therefore, that decreased excitability of the genital centre may cause impotence by provoking either a feeble and transient erection or no erection at all; and even if this first requisite is accomplished, the excitability of the centre may be insufficient to attain that intensity of nervous action required for ejaculation. Even if the genital centre be normally active, diminished excitability of the peripheral filaments in the glans and prostatic urethra will prevent the transmission of the usual stimulus to the centre which is normally aroused by friction of the glans.

Diminished excitability of the genital centre may be produced by disease of the lumbar cord—spinal meningitis, myelitis, tabes dorsalis; by various disorders of other organs which impair general nutrition—dyspepsia, diabetes, chronic nephritis, cachexiæ; by the prolonged use of certain drugs—opium, chloral, bromide of potassium, tobacco, alcohol, arsenic, antimony, lead, and, perhaps by the iodides (Bartholow); the impotence produced by the constant jarring of railway trains (of which I have seen several examples in railway employés and travelling men) probably belongs in this category. Impotence from such causes is comparatively rare, though the possibility of their existence should not be forgotten in determining the diagnosis and treatment, even when the more usual causes are present. In a few cases the impotence produced by masturbation or sexual

excess seems to be due to a similar condition of the genital centre ; these are recognized by the anæsthesia of the prostatic urethra upon the introduction of the sound.

The activity of the genital centre is sometimes repressed by the inhibitory influence of the brain ; this is the so-called *psychical* form of impotence. That sexual desire and vigor are diminished in a healthy man by depressing emotions, mental occupation, and nervous exhaustion is familiar ; and it would seem reasonable to assume that the same influences might attain such a degree as to entirely prevent the performance of the sexual function. Such instances have been actually observed, where impotence was caused by the loss of a beloved wife or child, of property, etc. (Ultzmann) ; it is also seen in cases where a man is unable to have intercourse with some particular woman, though perfectly potent with other females. Ultzmann had a patient whose wife applied for a divorce on the ground of his impotence ; the husband while admitting the charge so far as it concerned his wife, proved that there was no lack of virility in his relations with other women. In such cases the impotence manifested toward particular females arises from indifference or repugnance, whereby the activity of the genital centre is repressed by the psychical influence.

Impotence is sometimes caused entirely by the individual's fear that he may be unable to perform the act. Such fear is probably never entertained by a healthy and continent man ; it is inspired by some abnormality of the genitals which may possess no importance except to the ignorant imagination of the patient ; such conditions are diminutive size of the organs, varicocele, a gleety discharge ; or it may be suggested by a guilty consciousness of previous masturbation, gonorrhœa, or pollutions. We are told by most writers that psychical impotence is especially frequent in newly married men, produced by excessive desire and excitement. Premature ejaculation is certainly caused by these emotions and under these circumstances ; but impotence—including feebleness or utter failure of erection—I believe to be very rare in the newly married except when it is produced by the knowledge of previous abuse or disease of the sexual organs, often aggravated by a perusal of quack advertisements, and augumented by a sense of unworthiness to assume such a relation to a pure woman ; and in these cases it is possible that the failure is caused not alone by the psychical influence, but also by actual morbid conditions—chronic prostatitis or stricture—produced by previous sexual abuses, from the consciousness of which the individual's fear of failure arises. At any rate, a careful examination of the urethra and prostate should be made, especially if there be a history of masturbation or gonorrhœa, before the impotence is pronounced wholly psychical.

2. Overexcitability of the genital centre and of the peripheral nerves may be produced by interference with cerebral inhibition ; thus it is often observed in the early stages of tabes dorsalis involving the upper portions of the cord and thus relieving the lumbar centre from the usual control of the brain. In this disease erection and ejaculation are at first frequent and easily provoked ; indeed, nocturnal pollutions occur in those who have not previously been subject to them ; finally impotence results. Overexcitability of the same nature is seen in cases of injury to the cord, especially in the vicinity of (though not involving) the genital centre ; frequent erections, priapism, ejaculations without sexual excitement, and even an almost continuous expulsion of semen (Fürbringer) have been observed in such cases. Phosphorus, strychnine, and cantharides tend to increase potence, probably by exalting the reflex activity of the cord.

Undue excitability of the peripheral filaments is the most frequent cause of failure to properly perform the sexual act; in a very large percentage of cases of impotence there is found hyperæsthesia of the prostatic urethra. Such undue sensitiveness (accompanied doubtless by excessive reflex activity of the genital centre) is the usual result of excessive use of the sexual organs; in consequence of this condition erection is feeble and ejaculation premature; it is the condition commonly termed "irritable weakness." Irritability of other peripheral filaments than those distributed to the prostatic urethra may induce the same result; thus phimosis resulting in the irritation of the glans by retained smegma, fissures of the anus, hæmorrhoids, etc., produce an undue genital excitability which is manifested at first by nocturnal pollutions, and finally, if the cause still persist, by impotence. In some cases strictures, even those of large calibre, have contributed to a chronic irritation of the prostate, pollutions, and even impotence.

3. The congenital and acquired defects of the sexual organs productive of impotence are chiefly of two kinds: abnormalities of the penis rendering intromission impossible; defects of the testes preventing their activity and thus abolishing sexual desire. Among the former may be mentioned complete absence, a rudimentary condition, division of the organ (double penis); extreme dimensions from elephantiasis, preputial calculi; shortness of the frenum, adhesion of the penis to the scrotum, varix of the dorsal vein, distortion of the organ from congenital brevity of the corpus spongiosum, gummata of the corpora cavernosa, cicatrices from injury, abscess, or gangrene; indurated lumps in the corposa cavernosa (in a case reported by Van Buren and Keyes the penis was bent almost at a right angle). Such conditions are readily recognized from an examination of the organ and the statements of the patient.

The functional activity of the testes is absent or arrested, and sexual desire correspondingly diminished, by disease or removal of these organs, malignant tumors, tuberculosis, atrophy from inflammation, or complete occlusion of the vasa deferentia; the most frequent of these are bilateral syphilitic or tuberculous orchitis and double epididymitis. Disease or removal of one testis only does not usually diminish virility; yet it is to be noted that tuberculous inflammation of a testicle is apt to be followed by diminished potence and even sterility. In cases of syphilitic orchitis and gonorrhœal epididymitis recovery is possible through the continued use of mercurials and the iodide of potassium; and Wilson records a case in which an arrest of development of the testes was overcome by the stimulating influences of marriage, the organs being at the age of twenty-six no larger than those of a child, but increasing in size during two years of sexual activity almost to the usual adult dimensions.

Clinical History.—Impotence is a symptom; hence the constitutional symptoms exhibited are those of the original affection. Practically the condition is dependent upon hyperæsthesia of the prostatic urethra and is the last stage of sexual abuse. The usual history is, masturbation or venereal excesses, nocturnal pollutions, impotence; in general therefore the symptoms are those first brought to the notice of the physician in connection with pollutions; approaching impotence is indicated not by any constitutional disturbance but by feebleness of erection and premature ejaculation. Sexual desire is at first undiminished; but finally after erections have become so brief and imperfect and ejaculation so early as to render intercourse impossible, desire usually vanishes. In occasional cases desire persists after complete impotence and relaxation of the genitals render

intercourse or even erection impossible ; the patient attempts to gratify his longings by the most unnatural and loathsome methods of excitement.

The prognosis is far more favorable than the books generally lead us to infer. So long as erection however feeble, and ejaculation even if premature, are induced by normal sexual excitement, recovery is reasonably certain, even if the case be complicated by pollutions ; fortunately most cases are brought to the notice of the physician before they have passed this stage. When erections are feeble or absent, if desire is retained and erections with or without emissions occur during sleep, the prognosis is not unfavorable ; even when desire as well as erections have ceased there is a chance for recovery, especially if the patient be reasonably free from hypochondria and symptoms of nervous exhaustion.

As in cases of pollutions, the prognosis as to impotence is influenced by the age and temperament of the patient and the duration of the sexual excesses upon which the malady depends. Impotence occurring in a young man from excessive masturbation during boyhood is obstinate ; and when it begins after the age of forty-five, complete recovery can scarcely be expected. A nervous temperament predisposes to hypochondria, which constitutes a feature of obstinate and intractable cases.

The *diagnosis* of impotence rests upon the patient's statements ; the recognition of the cause must be determined by the history and by physical exploration. In every case the urethra should be explored with bulbous sounds or the urethrometer ; in almost every instance there will be found painfully sensitive points especially in the prostatic urethra, contractions of the urethral calibre, or both. The discovery of sensitive points with the bulb should be confirmed by the passage of an ordinary steel sound, since the former instrument may cause some pain in the normal urethra. There will also be found sensitiveness of the prostate upon rectal examination, perhaps a gleety discharge and often a feeling of weight in the perineum, and a history of pain during urination and ejaculation. These are the symptoms usually present, and indicate hyperæsthesia of the prostatic urethra—the commonest cause of impotence, producing feeble, transient erection and premature ejaculation.

In a smaller number of cases the prostatic urethra is not abnormally sensitive. This condition is found in two classes of cases: first, individuals of highly nervous organization and feeble physique, in whom a comparatively slight amount of sexual excess deranges the nervous mechanism before local changes in the prostatic urethra are produced ; and, second, cases in which the prostatic anæsthesia has been preceded by hyperæsthesia and irritability of the genitals. These are often robust individuals who have committed great excesses, have suffered from frequent pollutions, and have now arrived at a stage of almost complete impotence, where neither pollutions nor erections are longer possible. In the former class of cases—the nervous individuals—anæsthesia of the urethra is a favorable indication ; such cases require merely continence and constitutional treatment ; in the latter class the prostatic anæsthesia indicates exhaustion of the sexual apparatus, and calls for local as well as constitutional treatment.

The *treatment* in cases of impotence is pre-eminently a treatment of the individual and not of the impotence ; for this is but a symptom which may be dependent upon most diverse and often obscure causes. The promiscuous prescription of damiana, phosphorus, and other so-called aphrodisiacs is unreasonable and usually unsuccessful. No other morbid symptom calls for greater care in diagnosis, or discretion and tact in treatment than impotence.

Before instituting treatment the most searching investigation into the history, habits, general condition and state of the genital organs should be instituted. Even when the usual history of masturbation at some previous time has been confessed, the possibility that other causes are largely or entirely responsible for the impotence must not be forgotten. Even if the history indicates a purely psychical interference with the performance of the genital function, an examination of the urethra may reveal morbid changes which account for the impotence as well as for the patient's lack of confidence.

Difficulty is sometimes experienced in deciding whether other morbid symptoms present indicate the cause or the results of that condition upon which the impotence depends; thus chronic disorders of the stomach and bowels, albuminuria, and even glycosuria are not unusual symptoms. The relation of cause and effect can often be determined by the condition of the prostatic urethra; a lesion in this part renders it probable that the impotence has resulted from an abuse of the sexual function rather than from a constitutional disorder. An examination of the genital organs should always be made; since the impotence may be produced by phimosis, irritation of the glans, a short frenum, a stricture, etc., aggravated perhaps by sexual abuses. If there be a history of syphilis, a mercurial course is advisable even in the absence of orchitis.

If no morbid condition independent of the sexual apparatus and no local irritation of the genitals, anus, rectum, or bladder be discovered, the treatment is indicated by the general condition of the patient, the condition of the prostatic urethra, and the manner in which the sexual function is performed. Local hyperæsthesia of the prostate, combined with feeble, transient erections, premature (sometimes painful) ejaculation, present or previous nocturnal pollutions, and a persistence of sexual desire, is the group of symptoms most frequently presented to the physician. These indicate, in a vigorous individual, overexcitability of the genital spinal centre as well as of the peripheral filaments; and they call for measures both general and local which tend to diminish this excitability. These have been already described under the treatment of nocturnal pollutions, and need be merely mentioned here: the avoidance of sexual excitement of all kinds, active physical exercise, and constant mental employment; bromide of potassium in large doses, with or without quinine and iron, according to the patient's requirements; warm baths or hip-baths morning and evening; daily evacuations of the rectum; atropine if nocturnal pollutions are frequent. Locally the removal of stricture, contraction of the meatus, phimosis, etc.; the daily employment of steel sounds successively increasing in size until the full capacity of the urethra is attained; prostatic bougies containing silver-nitrate; and the local employment of galvanism. If the patient be feeble and nervous, the bromides and local treatment should be omitted, and attention given to the general health; for the sexual irritability is in this case usually a result of spinal debility or general neurasthenia.

The absence of prostatic hyperæsthesia calls for the employment of other measures. This condition, it is to be remembered, is found in different classes of patients; it is observed in highly nervous individuals who have not committed sexual excesses, and whose impotence is not dependent upon local abnormalities; it is also found as an advanced stage in robust individuals who have been guilty of excesses and have previously suffered from excessive pollutions; in such cases prostatic anæsthesia is often combined with complete absence of erections and ejaculations except as they occur during sleep when accompanied by lascivious

dreams. Finally, local anæsthesia occurs in patients who have been long treated for hyperæsthesia by the measures mentioned in the preceding paragraph. Impotence with prostatic anæsthesia, when it occurs in nervous individuals and is accompanied with pollutions and desire, requires no local treatment; tonics, strychnine, physical exercise, and encouragement are usually sufficient; when this condition is found, on the other hand, as a sequel to extreme irritability usually accompanied with pollutions, and in robust individuals, local treatment—nitrate of silver and the Faradic current—must be supplemented by strychnine, ergot, and atropia; the fluid extract of damiana, two to four teaspoonfuls three times daily, savine, or cantharides are sometimes useful. Cold hip-baths and cold douches to the lumbar region and perineum should be carefully employed; the temperature being gradually decreased from 65° to 45°. In one obstinate case, where there was almost complete absence of erections in attempts at intercourse and only occasional pollutions, a satisfactory degree of potence was regained within four months by massage of the genitals combined with cantharides and tonics.

In all cases the moral management is extremely important; the patient's confidence must be secured. It is rarely wise to belittle the gravity of the affection, even though only a slight degree of impotence be present; for the patient, thoroughly convinced of the serious nature of this complaint, is apt to regard such a course as indicating lack of sympathy or knowledge on the part of the physician. By admitting the present serious phases of the difficulty and by assurance that disastrous consequences can be averted and recovery secured by proper treatment and conscientious attention to directions on the part of the patient, his co-operation can usually be obtained and his melancholy in part at least dispelled. So soon as the first symptoms of improvement become manifest, the patient is invariably tempted to assure himself by the actual test of intercourse that he is improving; this should be prevented if possible, since a failure will seriously impair the progress and even the prognosis of the case. It is far better to forbid intercourse even after the improvement is such as to render success probable, for the patient will sooner or later make the attempt in spite of his physician's warnings, and the very consciousness that he is acting upon his own responsibility often tends to his success.

Sterility.

While it is true that impotence implies sterility, it is by no means a fact that potence secures fecundity. Natural desire, complete erection, copious and well-timed ejaculation and intense orgasm may all be exhibited by an absolutely sterile man. This fact, mentioned in every work upon the subject, must still be emphasized, because it is largely ignored in practice. The responsibility for a childless marriage is popularly and but too often professionally thrown upon the wife; an investigation of the husband is either omitted or limited to ascertaining that the act is normally performed. The wife falls into the hands of a gynecologist; intra-uterine applications are made, pessaries applied, perhaps the cervical canal is enlarged; yet no impregnation occurs, merely because no normal spermatozoa are deposited in the female organs. The few systematic examinations of the male fluid in cases of childless marriages have shown that in a considerable percentage (ten to thirty) the husband is sterile; hence in every case in which medical advice is sought as to the cause of barrenness

in marriage, the first examination should be directed to the semen, no matter how vigorous and potent the husband may be. By this plan the necessity for the violation of feminine delicacy by an inspection of the female organs is often avoided ; and the cause of the sterility is located far more definitely than is usually possible in the female, where we are generally compelled to assume the existence of an acrid secretion, an unnatural condition of mucous membranes, etc. The fecundating element of semen is the spermatozoa ; the absence or vital impairment of these cells, while perhaps affecting in no perceptible way the performance of the sexual act or the quantity and appearance of the fluid ejaculated, renders that fluid incapable of accomplishing its natural function.

Sterility without impotence may be due to either one or two causes ; the absence of normal spermatozoa from the semen—azoöspermism ; or the failure to ejaculate—aspermatism.

In *aspermatism* the contents of the seminal vesicles are not ejaculated, either because that fluid does not enter the urethra or because its further progress is prevented by some obstacle in this channel. In the former case the prostatic and urethral secretions which enter into the composition of semen may be expelled during intercourse, though not with the usual force. Aspermatism is congenital or acquired, permanent or temporary ; the acquired and the temporary cases are most frequent. The failure to ejaculate may be caused by mechanical obstruction in the ejaculatory ducts or the urethra, by deficient excitability of the genital centre in the lumbar cord, by diminished sensibility of the peripheral nerves, and finally by undue inhibition of the spinal centre by the brain.

The mechanical causes of aspermatism are congenital defects or malformations, inflammatory occlusions, concretions formed in the seminal vesicles or prostate, urethral stricture, contracted meatus, tight phimosis. The congenital deformities are rare ; Schmidt observed a man whose prostate and seminal vesicles appeared to be undeveloped ; he had never ejaculated, though quite potent. Ultzmann had a patient twenty-four years of age whose genital organs were apparently normal and had never been diseased, who nevertheless, although potent, had never had an emission ; this may have arisen from absence of the ejaculatory ducts (a specimen of which condition exists in the Hunterian Museum) or it may have resulted, as Ultzmann is inclined to think, from deficient excitability of the genital centre.

Occlusion of the ejaculatory ducts or misdirection of their orifices is a not infrequent result of injury or inflammation ; it can also be produced by simple non-inflammatory hypertrophy of the prostate. Aspermatism has been thus produced by perineal abscess (Kocher), lithotomy (Teevan), cicatrix in the prostatic urethra after gonorrhœa, etc.

Concretions composed of spermatozoa and calcic salts are occasionally formed in the seminal vesicles, and may even attain the size of a cherry (Beckmann) ; the occlusion of both ejaculatory ducts by such concretions would necessarily cause aspermatism ; indeed, Reliquet observed three cases in which ejaculation was prevented, although only one duct was occluded, presumably because the distended duct compressed and thus occluded the other one. In a case observed by Bergh temporary aspermatism was relieved by the expulsion, during intercourse, of numerous concretions with the semen.

In the conditions already mentioned there has sometimes been found an unusual distention of the seminal vesicles, and occasionally a feeling of distention during intercourse.

A far more frequent cause of aspermatism is urethral stricture ; even a

contraction of such large calibre as affords no serious obstacle to urination may, when aided by the compression which the urethra naturally suffers during erection, prevent the passage of semen ; it is possible, as suggested by Gross, that the occlusion is produced wholly or partly by spasmodic contraction of the sensitive urethra at the strictured point. A contracted meatus or a tight phimosis may likewise mechanically prevent the discharge of semen.

Aspermatism is occasionally acquired through the same sexual excesses that produce impotence, of which, indeed, the failure to ejaculate may be regarded as the initial stage. Through masturbation, venereal excess, or gonorrhœa the excitability of the peripheral filaments or the genital centre may be so decreased that the intense nervous stimulus required for ejaculation cannot be exerted, although erections may be complete ; intercourse, though long continued, does not culminate in orgasm or ejaculation. Such subjects usually exhibit the symptoms of sexual exhaustion, and upon exploration of the urethra hyperæsthesia of the canal, especially in the prostatic portion, is often found ; the condition is, indeed, an advanced stage of that which produces nocturnal pollutions, which may occur during sleep even when prolonged intercourse does not produce ejaculation.

That aspermatism may be the result of deficient sensibility in the peripheral nerves was demonstrated by Curling in the case of a young man with congenital absence of the prepuce. Although he had an occasional nocturnal pollution, this patient had never been able to ejaculate during intercourse until Curling applied acetum cantharidis to the glans, after which intercourse was normally completed. In another case recorded by the same surgeon, ejaculation became impossible after syphilitic ulceration had destroyed the prepuce and converted a large part of the surface of the penis into a scar.

The same mental conditions and emotions—preoccupation, repugnance, fear, etc.—which may produce complete impotence can be exhibited in the less intense degree of aspermatism ; erections occur, but emission is impossible. Such aspermatism, like psychicial impotence, is temporary or manifested only toward certain women.

The treatment is indicated entirely by the cause.

Azoöspermism—the absence from the semen of fertile spermatozoa—is the most frequent cause of masculine sterility, and is a *by no means rare condition*. It may exist without any suggestion of impotence, without any history of sexual excesses ; in short, where neither the history, the examination of the genitals, the macroscopic inspection of the semen, nor any other circumstance arouses a suspicion of sterility. The effort to explain the barrenness of a marriage should therefore *always begin with the husband*, and should include a macroscopic examination of the semen, no matter how vigorous, potent, and free from sexual disorders the man may be. In fourteen out of forty cases of childless marriages Kehrer found the cause of sterility in the husband's azoöspermism.

The infecundity of semen depends upon either (1) the absence of spermatozoa, or (2) the loss of vital properties in those which may be present. In either case the semen may exhibit the same gross appearances as normal seminal fluid ; the microscope alone reveals its worthlessness for purposes of impregnation.

(1.) The most frequent causes for the absence of spermatozoa are bilateral obliteration of the epididymis and vas deferens ; bilateral (and extensive) orchitis, whether tubercular, syphilitic, or simple, and arrest of development or atrophy of the testes ; the latter condition is frequent when the testicles fail to descend into the scrotum (cryptorchids). Bilateral

obliteration of the epididymis is usually a sequel to gonorrhœa, but is produced also by syphilitic and tuberculous inflammation. When of tubercular origin, the occlusion of the ducts and consequent azoöspermism are permanent; while the obliteration caused by syphilitic or gonorrhœal inflammation has been occasionally relieved by treatment. Of 83 cases of double gonorrhœal epididymitis observed and collected by Liégeois, spermatozoa reappeared in the semen of 8; in the remaining 75 cases the azoöspermism was permanent. Kehrer emphasizes the fact—of which I have seen two illustrations—that the azoöspermism due to double gonorrhœal epididymitis sometimes persists even after the inflammatory products have been absorbed and the epididymis has become normal in size and consistence; the patient is permanently sterile, though the genitals reveal no abnormality. It occasionally happens that unilateral gonorrhœal epididymitis causes complete and permanent azoöspermism and sterility, either through an intimate sympathy between the testes, or from some undiscovered anatomical change.

Unilateral tubercular epididymitis usually renders the patient sterile; according to Godard's observations, the sterility (from azoöspermism) may exist for a year or two before the tuberculous affection becomes manifest.

(2.) The natural fertilizing power of the spermatozoa is lost during various abnormal constitutional and local conditions; during many acute inflammatory affections and chronic diseases of the nervous system and of the urinary organs the production of spermatozoa is diminished or arrested, though potence may remain for a time unimpaired; the number of the spermatic cells is decreased, and their movements are less vigorous. Even simple neurasthenia without previous sexual abuse may seriously impair the vitality of the spermatozoa. Sexual excesses, whether by intercourse or masturbation, cause a diminution in the number and activity of these cells, or even their complete disapperance from the semen—an effect which is transient or permanent according to the degree and duration of the excesses. In the semen of a man examined three months after his marriage —during which period he had indulged in intercourse two or three times almost every night—I found comparatively few spermatozoa, which were moreover small and almost motionless; a year later, and three weeks after his wife's confinement, they were numerous and active.

Of the local abnormal conditions which destroy the fertilizing power of spermatozoa, the most frequent is catarrh of some portion of the seminal passages; the admixture of such inflammatory products with the semen often renders the spermatozoa motionless. Hence sterility may result from gonorrhœa, not only through occlusion of the ducts (epididymitis), but also through the establishment of chronic catarrh of the seminal vesicles, prostate, or posterior urethra.

In occasional cases the spermatozoa are of normal size and appearance, and yet exhibit little or no movement, although no catarrh of the seminal passages can be detected; the lack of motion may depend upon an abnormal density or reaction of the semen; for active movements can sometimes be provoked by adding a few drops of tepid water, or of a one per cent. solution of sodium carbonate. Gross cites a case in which the lack of movement of the spermatozoa was attributed to abnormal density of semen, "so that the injection of a small amount of lukewarm water into the vagina after coition was advised, and the woman subsequently bore several children."

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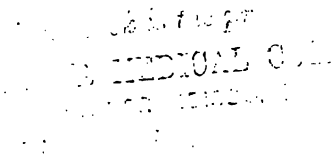


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