THE DIAGNOSIS OF URINARY CALCULI.

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The introduction and the modern perfection of radiology and of urological examinations have enormously simplified the diagnosis of calculi situated in any part of the urinary tract, but it should be recognized that a radiological examination should only form one link in the chain of evidence and should be used to confirm or to disprove any suspicion that arises from the clinical evidence.

In many cases the practitioner when he first examines his patient will not have the advantage of an X-ray examination and, even if this should be the case, he may have some difficulty in the interpretation of the film presented to him and it is with these two points in view that this article has been written.

Calculi may be present in the kidney, in the ureter, in the bladder, prostate or in the urethra and it will be necessary to consider each of these situations in some detail.

I. RENAL CALCULUS.

Before discussing the diagnosis of a renal calculus, it is necessary to have a clear conception of the symptoms that may be caused by a stone in the kidney. A calculus may be present in the kidney for years, slowly enlarging and slowly destroying the renal tissue. Sooner or later a hæmatogenous infection will occur and the urine become clouded with pus. Contrary to the general opinion a large calculus may give rise to very little discomfort, whereas a small calculus lying in the renal pelvis may give rise to severe pain. The *classical symptoms* of renal calculus are *pain*, *hæmaturia* and *pyuria*.

Pain is present in the majority of cases. It may occur as a fixed pain, as a definite attack of severe colic or as a referred pain. The fixed pain is felt in the posterior renal area in the angle between the last rib and outer border of the erector spinæ muscle. The pain is described as a dull ache, increased by exercise or exertion or by any jarring movement such as jumping, motoring, etc.

Renal colic is a severe pain due to increased tension in the renal pelvis and ureter from the attempt to pass on a calculus or some solid material by peristaltic action. The pain commences in the posterior renal area, passes forward under the costal margin and downward along the course of the ureter to the external abdominal ring and may shoot into the testicle of the same side or to the tip of the penis. In some cases it passes into the anterior surface of the thigh or along the course of the sciatic nerve. There is frequently severe and urgent desire to micturate, although the amount of urine passed is small. The attack is frequently followed by the presence of blood in the urine and later a small calculus may be passed *per urethram*. The pain may be so severe as to cause sweating, vomiting or collapse.

Referred pain to a distant part is occasionally present with renal stone. It may be in the testicle, in the distribution of the anterior crural or sciatic nerve, even to the sole of the foot, or may exceptionally be referred to the opposite kidney (reno-renal reflex).

Hæmaturia is present in many cases, but is seldom severe and frequently is not perceived by the patient and only shown to be present on microscopical examination. It is usually present immediately after an attack of colic or may be caused by exertion or jolting movements.

Pyuria again may be slight and only microscopic, but when infection is marked the urine may be heavily loaded with pus. It may be taken as a general axiom that when a patient passes highly purulent urine without pain, increased frequency or pain on micturition, to suspect a large calculus in one kidney. A renal calculus may remain quiescent, may pass into the ureter and cause renal colic or give rise to obstruction to the normal passage of urine along the ureter causing hydronephrosis; if infection should occur there may be symptoms of pyelitis, pyonephrosis or perinephritis with abscess formation which may obscure those caused by the presence of the calculus.

The *physical examination* of a patient the subject of a renal calculus may show little abnormality. In the intervals between the attacks of acute colic there may be some tenderness on deep palpation in the loin on deep inspiration. Jordan Lloyd stated that if sudden pressure be made in the subcostal area, a sensation of pricking will be felt by the patient if a renal stone is present, but personally I have found this sign of very little value. The kidney may be felt to be enlarged if any dilatation is present, more especially if infection be present and infiltration in the perinephric tissue will give the feeling of an enlarged kidney, though the usual downward excursion on deep inspiration will be limited. In thin patients a large calculus may be rarely palpated and in cases in which multiple calculi are present, crepitation may be felt.

In acute perinephritis there may be oedema of the skin of the loin immediately below the last rib, whilst if suppuration has occurred there may be in addition cutaneous redness in this area.

If the patient is seen during an attack of renal colic, he will be in obvious severe pain, writhing in bed, sweating and often vomiting. The upper rectus muscle is retracted and rigid and there is increased muscular resistance in the lumbar muscles. The patient will point to his side, grasping his loin between his fingers and thumb and passing his hand downwards towards the groin.

Examination of the urine may show a trace of albumin in the quiescent stage and a microscopic examination may show red blood discs, hyaline casts and urinary crystals, whilst if infection is present pus will be present in varying quantity.

Cystoscopic examination may be helpful in the diagnosis of a renal stone. When hæmaturia is present, a blood stained efflux may be seen from one ureteric orifice, whilst infection in the kidney may give an efflux clouded with pus or containing flakes of muco-pus. The actual appearance of the ureteric orifice is usually unchanged, though where infection is present the edges of the orifice may appear thickened and the immediate vesical mucous membrane surrounding the orifice may be slightly reddened. In old standing cases of renal infection from a calculus, the ureteric orifice may be patent, rounded and rigid and thick pus may be seen to be slowly extruded from it. The chief advantage, however, of a cystoscopic examination is to eliminate other diseases which might be present, for the purpose of ureteric catheterisation and to prove the functional efficiency of the kidney of the other side.

The *diagnosis* of renal calculus may not be easy as similar symptoms may be produced by varied lesions of the kidney. A **renal growth** usually gives rise to intermittent attacks of profuse hæmaturia, not related to exertion, and pain similar to renal colic may be caused by the passage of blood clot along the ureter. These may be found as long, tapering, worm-like clots when subsequently passed in the urine. A renal growth may be felt as a nodular, firm swelling on bimanual palpation in the loin which is distinguished from the fluid distension of the kidney with hydronephrosis or pyonephrosis. Calculus disease rarely causes profuse hæmaturia and usually occurs at an earlier age than growth.

A **movable kidney** may give rise to pain very suggestive of renal colic and may occasionally give rise to hæmaturia, both of which, as is the case with the calculus, may be precipitated by excessive movement or jolting. A movable kidney usually occurs in thin women and is easily palpated and replaced into the renal fossa, but it should be remembered that a movable kidney may contain a calculus necessitating an X-ray examination before any treatment for the mobility is undertaken.

Renal tuberculosis may occasionally be mistaken for calculus disease. The subject of tuberculosis will, however, usually be a young adult between the ages of 15 and 25, will give a history of gradually increasing frequency of micturition with pain after voiding and presenting a urine containing pus and a few red blood cells. Tubercle bacilli may be found in the urine, or, if absent in a suspected case, inoculation of the centrifuged deposit should be made into a guinea-pig. In most cases an old tuberculous lesion will be found present in the chest or in a joint antedating the urinary infection. A cystoscopic examination may show evidence of tuberculous infection in the bladder or changes about the ureteric orifice of the diseased side. Tuberculous disease of the kidney may give rise to renal colic from the passage of caseous material down the ureter and may occasionally give rise to an ill-defined mottled area in the renal area on radiographic examination. Renal tuberculosis is accompanied by a descending tuberculous infection of the ureter which may be felt as a thickened cord *per rectum* or *per vaginam*, or in the male tuberculous foci may be palpated in the epididymis, prostate or seminal vesicle.

An early **hydronephrosis** may cause pain from increased renal tension very similar to renal colic, but is not usually accompanied by hæmaturia or pyuria. The onset of the pain is more gradual with hydronephrosis. Not infrequently some congenital narrowing or displacement of the uretero-pelvic junction, or abnormal arrangement of the renal vessels by which the upper ureter becomes partially obstructed, may cause dilatation of the renal pelvis leading to hydronephrosis and no doubt many of these cases underwent an exploratory operation for calculus before radiographic examination was possible. By the increased facilities now offered to the surgeon by radiography and pyelography the diagnosis of early pelvic hydronephrosis from calculus is not difficult.

Oxaluria, the passage of a concentrated urine containing crystals of calcium oxalate, may cause renal colic, hæmaturia and increased frequency of micturition. This condition is most frequently seen in children in the early summer during the strawberry season and is quickly relieved by appropriate treatment with alkalis and diuretics.

Nephritis associated with hæmaturia may cause difficulty in diagnosis, but the microscopic examination of the urine will show the presence of casts, whilst albumin will be present in the absence of blood. In many cases the nephritis may be of a toxic origin when a septic focus should be sought for in the tonsils or nasal passages.

Acute hæmotogenous infection of the renal pelvis usually commences with a rigor and the temperature is raised and irregular. There may be pain in the loin, radiating downwards to the groin and there may be microscopic blood and pus in the urine. The symptoms are very similar to those which occur when a kidney containing a calculus becomes acutely infected.

Gallstones may give rise to acute pain resembling renal colic, but the pain is felt under the right costal margin rather than in the loin and radiates to the epigastrium and towards the right scapula rather than downwards along the line of the ureter. There is usually a history of repeated indigestion unrelated to the ingestion of food. Gallstones will not be accompanied by hæmaturia after the cessation of pain.

Spinal disease—either tuberculous or osteoarthritic—may give rise to symptoms similar to renal calculus. The pain, however, does not spread to the testicle and there is no microscopic change in the urine. An X-ray examination of the vertebral column will show definite changes in the outlines of the vertebræ and the absence of a shadow in the renal area.

Tabes dorsalis may be accompanied by the acute pain of a crisis which may resemble renal colic, but the absence of any change in the urine, together with other symptoms of the disease with a positive Wassermann reaction in the cerebrospinal fluid will point to the true diagnosis.

Acute appendicitis has frequently been diagnosed when a calculus is present in the kidney or in the ureter. If the kidney is prolapsed and a painful swelling is present in the right iliac fossa the diagnosis may be very difficult. With appendicitis there may also be slight hæmaturia and increased frequency of micturition, but an increased polymorphonuclear leucocytosis will be present which does not occur with renal stone unless a closed pyonephrosis is present. Pyrexia and Rosving's sign, namely an increase in local pain when pressure is made on the descending colon, will be present in appendicitis, whilst there may be tenderness and swelling in the right pelvic space on rectal examination. The patient shows more sign of general illness with acute appendicitis than in renal colic.

Radiographic Examination.

Radiography affords such important evidence in the diagnosis of a renal calculus that every case in which a calculus is suspected should be submitted to an X-ray examination. Certainly no operation should be carried out on the kidney without such an examination,—except perhaps in a few cases of grave emergency to evacuate pus from an acute pyonephrosis or suppurative perinephritis.

A radiographic examination should cover the whole urinary tract, the kidneys, the ureters and the bladder and should preferably be of short exposure with a soft tube. The kidneys should be immobilized during the exposure by instructing the patient to hold his breath and it is advantageous to take a film at the end of both full inspiration and full expiration. A good X-ray film of the

renal areas should show not only the eleventh and twelfth ribs and the iliac crest, but the whole of the lumbar spine, the outer oblique margin of the psoas muscle and the outline of the lower half of the kidney each side. There should be a narrow space between the outer border of the psoas muscle and the renal shadow. In full inspiration the kidney descends with the diaphragm and the renal pelvis is on a horizontal line with the body of the second lumbar vertebra, whilst the lower border of the kidney is on the same plane as the intervertebral disc between the third and fourth vertebræ. The object of taking a radiographic film in both deep inspiration and expiration is to ascertain whether any suspicious shadow in the renal area has the same excursion of movement as the renal shadow itself and this forms an important piece of evidence in a doubtful case.

The density of the shadow of a renal calculus in an X-ray film varies with its chemical composition and upon its size. Calculi composed chiefly of calcium oxalate yield the most dense shadow, whilst those composed of carbonates, phosphates and cystine give a moderately dense shadow. Calculi composed of urates only give a faint shadow, whilst stones of pure uric acid may show no shadow. Uric acid calculi are, however, usually small and of smooth surface and in consequence are frequently passed naturally. Radiologists now claim that at least 98 per cent. of renal calculi should be clearly shown on a good radiogram.

The shadow of a renal calculus should be sharply defined if the kidney has been immobile during the exposure. It is nearly always of uniform density throughout. A calculus lying in the renal pelvis is often triangular in shape, lies opposite the body of the second lumbar vertebra during full inspiration and occupies the space between the renal shadow and the outer border of the psoas muscle. A calculus in the lower calyx of the kidney lies opposite the third lumbar vertebra unless the kidney is dropped and is usually of rounded or dumb-bell form, but calculi only rarely occupy the upper calyx. There may be multiple shadows in the renal area or a pelvic stone may show processes extending into the calices (dendritic calculus). If multiple shadows are present separated from each other, it suggests that the kidney is dilated.

The differential diagnosis of a shadow seen on an X-ray film in the renal area may not be so easy as would appear from the above, and the practitioner should be fully acquainted with the pitfalls in the interpretation of the film. Shortly, however, a renal calculus should cast a shadow of uniform density, with margins clearly defined provided no movement has taken place, should occupy a position in the renal area and move equally with the lower border of the renal shadow on respiratory movements. Little can be said from the shape of the shadow of a calculus which may be round, oval or triangular in the renal pelvis or may show a cast of the lower or middle calyx.

If a radiograph be taken in a lateral plane, the shadow of a renal calculus should be superimposed on the bodies of the second or third lumbar vertebræ. (Fig. 10.) The renal outline cannot be seen in a lateral view, but the method is useful in differentiating a shadow which might occupy the renal area in an antero-posterior film. Thus the shadow of a gallstone (Fig. 11) or of some intestinal content would be well in front of the spine, but it must not be forgotten that a calculus situated in a kidney dilated into a hydro- or pyo-nephrosis may appear well in front of the spine in the lateral view.

The only probable lesion in the kidney to cast a shadow in the renal area is an area of caseation or calcification of a tuberculous focus. These shadows are less dense than those of calculi, are mottled in appearance from irregularity of density and have an ill-defined margin. These shadows also occupy a position at the outer portion of the renal shadow and are sometimes wedge-shaped with the base towards the renal cortex. In a case in which such a shadow is present there will in all probability be other signs of urinary tuberculosis, such as frequency and pain on micturition, constant pyuria and the presence of tubercle bacilli in the urine. The palpation of a thickened lower ureter *per rectum* or *per vaginam* and the changes in the appearance of the ureteric orifice or of tuberculous foci in the bladder seen on the cystoscopic examination will point to the diagnosis. In an occasional case of renal tuberculosis in which a shadow may be present, pyuria may be absent from blockage of the ureter of the affected side. The calcification of the wall of a hydatid cyst in the kidney may give rise to a shadow in the renal area, but these cases are very rare in this country.

Other conditions in no way connected with renal disease may throw a shadow in the renal area which must be distinguished from renal calculi. Gallstones may cast a faint shadow in the renal area in an antero-posterior film, but there is frequently a more marked peripheral density giving a ring-like appearance to the shadow. Gallstones may be multiple in which case the shadows may appear to be of cubical or pyramidal shape. In a lateral radiogram the shadow occupies a position well anterior in the abdomen. (Fig. 11.) In cases of difficulty a further X-ray film should be taken twelve hours after an intravenous injection of tetraiodo-phenolphthalein when the gall-bladder may be outlined and the calculi seen as filling defects in the shadow caused by the dye. A stone in the common bile duct may cast a shadow in the posterior abdomen in a lateral radiogram.

Calcified tuberculous glands frequently are seen in a radiogram of the abdomen and, if associated with urinary symptoms, may be mistaken for calculi. These glands are present in the mesentery of the small intestine or in the retro-colic group close to the spine. The latter may form a shadow in the renal area, but tuberculous mesenteric glands more frequently cast a shadow in the iliovertebral angle and are more likely to be looked upon as ureteric calculi. (Fig. 12.) The shadows formed by calcified tuberculous glands are irregular in outline, of non-homogeneous, mottled appearance and are particularly likely to occupy a different position in successive radiograms, or on manipulation, owing to their mobility with the intestine. Where difficulty is experienced a further radiogram, preferably a stereoscopic pair, should be taken after a radiographic catheter has been passed the whole length of the ureter when the shadows will be seen to occupy a position in front of the urinary tract. A lateral radiogram may show mesenteric glands to be well in front of the spine, but a retrocolic gland may be only just in front or actually superimposed upon the bodies of the vertebrae.

Calcification of the costal cartilages may cast a shadow in the radiogram of the renal area, but the shadows are irregular in outline, usually multiple and occupy a very anterior position in a lateral view. It is a fairly common feature in old age, but may occur in patients of 30 years.

Intestinal contents may sometimes cause a shadow in a radiogram, usually diffuse and of uneven density and little likely to be mistaken for a renal calculus. A concretion in the appendix might mimic a ureteric stone, but would be easily differentiated by a subsequent stereoscopic X-ray picture with a catheter in the

ureter. Gas in the large intestine may give trouble in obscuring the renal shadow or that of a calculus, necessitating a further examination after careful preparation with aperients. Saline purges and enemata should be forbidden before any radiographic examination.

A tumour of the skin may cast a shadow on a radiogram and may happen to coincide with the renal area. In one case a small pedunculated fibroid of the skin of the back cast a smooth rounded shadow and Swift Joly reports a case in which a large wart on the back threw a shadow which was diagnosed as a renal calculus.

Pyelography.

The radiographic examination of any case of suspected calculus is not complete without a pyelographic examination, that is the delineation of the renal pelvis and calices after the latter have been filled with a fluid opaque to the X-rays. Whereas formerly this necessitated the passage of a ureteric catheter through a cystoscope, followed by the injection of some radio-opaque solution such as sodium iodide or bromide, it can now be carried out after the intravenous injection of fluids such as uroselectan-B or abrodil. By means of pyelography not only can the exact position of a doubtful shadow be determined, but the anatomical condition of the kidney can be seen and the amount of dilatation of the pelvis or calices ascertained before operation is undertaken. In some cases a comparatively small stone in the renal pelvis may cause considerable dilatation by obstruction and the knowledge of such a condition may determine the nature of the operation to be undertaken. Intravenous pyelography may also be used as a functional test of each kidney, for whereas the excretion of the dye should be seen in the kidney within five minutes from the time of injection, delay in the appearance will indicate diminution of the functional efficiency of the kidney. Pyelography is extremely useful in the diagnosis of early hydronephrosis, renal tuberculosis, renal neoplasm or in polycystic disease, and in those exceptional cases of calculus not shown in a radiogram a pyelographic picture may reveal a "filling defect" in the renal pelvis occupied by the calculus.

2. URETERIC CALCULI.

Calculi in the ureter have practically always descended from the kidney and have become arrested during their passage downwards. Very exceptionally a calculus may be formed in the ureter around a suture used in a previous operation or in an area of ulceration caused by a former calculus. The normal ureter is not of the same calibre throughout its length, the lumen being narrowed just below the junction of the ureter and the renal pelvis, at the brim of the true pelvis and particularly in the terminal 2 cm. of its length where it passes obliquely through the vesical wall. It is in these three situations that a descending calculus is most likely to be arrested.

A calculus, having once commenced to descend the ureter during an attack of colic, may traverse the length of the ureter, pass into the bladder and be later passed *per urethram*. On the other hand, it may become arrested, causing occasionally complete occlusion of the ureter or more frequently partial obstruction, allowing the passage of urine, but causing gradually increasing dilatation of the proximal ureter, the renal pelvis and calices with progressive destruction of the renal tissue. At the same time the calculus gradually increases in size by

further deposition of urinary salts and assumes a shape like an almond or a date stone. The descending calculus is usually small at first, perhaps no larger than a grape pip; most frequently it is composed of calcium oxalate, rough and crystalline on the surface and therefore more liable to be arrested in the mucous membrane lining of the ureter. A smooth-surfaced uric acid calculus is more likely to pass down the ureter. If any infection occurs, there is more rapid deposition of phosphates so that the calculus becomes formed of a nucleus of oxalate and a surrounding coating of phosphate and may appear laminated on X-ray examination.

A calculus may remain arrested in the ureter for a considerable time during which gradual changes occur in the upper ureter and renal pelvis, whilst if infection occurs, the symptoms of pyonephrosis become more pronounced. Whilst a calculus remains in the ureter, it sets up a train of symptoms varying somewhat according to the position of the calculus. Thus if arrested close to the renal pelvis, the symptoms are practically the same as a calculus in the pelvis, recurrent attacks of acute renal colic followed by slight hæmaturia and often by a trace of pus. A calculus arrested in the ureter at the brim of the bony pelvis usually gives rise to constant pain just internal to the anterior superior iliac spine associated with aching in the renal angle posteriorly and the presence of traces of blood and pus in the urine. If the calculus is impacted in the terminal ureter, the symptoms are those of a vesical lesion, increased frequency of micturition with pain in the glans penis or vulva immediately following urination, together with slight hæmaturia and a constant ache in the groin over the external abdominal ring.

Physical examination in a case of ureteric calculus may reveal tenderness on pressure along the course of the ureter together with tenderness about the kidney on bimanual palpation, whilst occasionally a calculus in the terminal ureter may be felt in the lateral fornix on vaginal examination. Exceptionally a calculus may be felt in the male *per rectum* in a thin subject.

Cystoscopic evidence of the presence of a calculus in the ureter is very variable. After a recent attack of acute colic, there may be small areas of sub-mucous hæmorrhage around the ureteric orifice, especially on the upper and outer aspect over the intramural portion of the ureter. The orifice itself may show no change and the urinary efflux may be forcible and normal. On the other hand, a calculus impacted in the terminal ureter may show characteristic changes which are diagnostic. The orifice pouts and peristaltic movements may be forcible. At the same time there is oedema of the vesical mucous membrane with dusky discoloration surrounding the orifice. Sometimes the area surrounding the orifice becomes raised into small transparent nodules, called "bulbous oedema". In other cases, a distinct bulge may be seen present just above and outside the ureteric orifice formed by the calculus in the transmural position of the ureter; occasionally the lower end of the calculus can actually be seen to project from the patent ureteric orifice at each peristaltic contraction. In a few cases the lower end of the ureter balloons into the bladder with each systole, the actual orifice being quite small, whilst in one case under my care the whole lower end of the oedematous ureter was prolapsed into the bladder forming a tumour which was diagnosed from its cystoscopic appearance as a villous-covered carcinoma.

Catheterisation of the ureter may result in the arrest of the catheter by the stone, or more frequently the catheter passes alongside the stone into the ureter proximal to it. It is seldom that the calculus can be actually felt during the passage of the catheter, although a slight hitch in the even passage of the catheter may be noticed. If the catheter can be passed into the renal pelvis, that is to a distance of about 23 cm. from the vesical orifice of the ureter, the character of the urinary drip from the distal end of the catheter should be noticed; if the renal pelvis is dilated, the urine will flow from the catheter in even regular drops, as opposed to the intermittent few drops at regular intervals from a normal kidney.

Radiographic examination should always be undertaken in a suspected case of ureteric calculus. (Fig. 13.) The shadow of a ureteric stone is usually well defined, of uniform density, though it may show a denser central portion if it has remained in the ureter for some time. It is commonly oval in shape with the long axis in the direction of the line of the ureter, that is mainly vertical in the abdominal ureter, but inclined downwards and inwards as the ureter approaches the bladder. Should any difficulty arise in the interpretation of a shadow suspected to be a ureteric calculus, a further radiogram should be taken after the passage of an opaque ureteric catheter, preferably by means of a stereoscopic pair so that the exact relations of the shadow to the ureter can be seen. (Fig. 14.) The tip of the catheter may be arrested by the calculus or may pass alongside it, but the stereoscopic picture will show that the shadows of the catheter and the stone are in the same plane. If the suspected shadow is not that of a ureteric stone, the stereoscopic view will show it to be at one side or in front of the opaque catheter.

The *diagnosis* of a stone in the ureter is usually easy when a complete examination has been carried out, but occasionally difficulty may arise in cases in which a radiogram is not available or in the interpretation of a shadow. The actual descent of a calculus from the kidney into the ureter is accompanied by severe pain in the renal angle, passing downwards in the line of the ureter and may be associated with vomiting, abdominal rigidity and distension. The case may seem to be one of abdominal emergency and if on the right side may be mistaken for **acute appendicitis**. In the latter, however, there is more constitutional disturbance, the tongue is coated, the temperature is slightly raised and the pulse rate slowly increases. In appendicitis, pressure on the left side of the abdomen may increase the pain in the right iliac fossa (Rosving's Sign) and there will seldom be the same amount of pain on pressure in the renal angle posteriorly. The presence of blood or pus in the urine will be in favour of a calculus, but it must not be forgotten that both may be present in acute appendicitis when the inflamed appendix turns downwards into the pelvis.

The sudden onset of an **acute hæmatogenous pyelitis** may cause some difficulty in diagnosis owing to the presence of pain in the loin passing along the line of the ureter with increased frequency of micturition and slight hæmaturia. In these cases the pain is not so severe and the onset is often accompanied by a rigor and pyrexia to 103°F. The pain is rarely so unilateral as in a calculus. The presence of organisms in the urine will point to the true diagnosis.

The acute colic of a **gallstone** is more often mistaken for a renal than a ureteric calculus. The pain is more subcostal and passes backwards and upwards towards the angle of the scapula rather than downwards in the line of the ureter. The abdominal rigidity is in the epigastric area with biliary colic rather than in the iliac area with a descending calculus and there is frequently a history of dyspeptic symptoms.

In cases in which a shadow is present in a radiogram, the uniform density, the oval shape in the line of the ureter and the position are fairly diagnostic, but a shadow in the line of the ureter may be caused by other conditions than a stone. A concretion in the appendix or some **intestinal content** such as a pill containing iron or bismuth may cause misgiving, whilst **calcareous tuberculous mesenteric glands** may give rise to a shadow in the line of the ureter. These are frequently multiple, are of uneven, irregular density and movable. The diagnosis from a ureteric calculus will easily be made by means of a stereoscopic radiogram after the passage of an opaque catheter into the ureter.

Shadows may be present in the pelvis due to **phleboliths** in the pelvic veins. These form small rounded, defined shadows, usually multiple, and on both sides close to the pelvic brim. One such shadow may occasionally cause difficulty in diagnosis, but stereoscopic films with a radio-opaque catheter in the ureter will show the shadow to be outside the line of the ureter.

Atheroma of the wall of the common or internal iliac artery may cast a shadow in a radiogram in the line of the ureter, but the shadow is usually only faint, of irregular outline and with slightly increased peripheral density.

A small calculus lying in a **diverticulum** of the bladder may cause confusion. A calculus lying free in the bladder usually occupies the middle line, is oval in shape with the long axis horizontal. A calculus in the terminal ureter may sometimes be nearly horizontal in position, but to one side of the middle line, and the same position may be occupied by a stone in a vesical diverticulum. The diagnosis will be made by a cystoscopic examination or by means of a cystogram.

3. VESICAL CALCULUS.

A patient the subject of a vesical calculus will give a very definite train of symptoms provided the condition is not complicated by urinary obstruction or vesical infection, both of which mask the picture considerably. In the ordinary non-infected case the patient complains of pain in the glans penis coming on at the termination of micturition and lasting for some few minutes after the act, —a symptom particularly marked in children. There is usually hæmaturia which is characterized by the fact that the early urine passed is clear, but the terminal few drops are tinged with blood. The desire to micturate becomes urgent, especially on any sudden movement, such as rising from a sitting position or any jolting as in a train or motor journey, whilst more active movements such as dancing or horse-riding give rise to marked desire to void urine. Frequency of micturition is therefore present during the day, but provided no infection has occurred, the patient will not be disturbed during the sleeping hours. A common sign of calculus in the bladder is a sudden interruption in the stream of urine during micturition, the stream being suddenly arrested with pain in the glans penis and recommencing after a few seconds. This symptom is commonly described as due to the impaction of a small stone in the internal urethral orifice or to the sudden closure of the orifice by the stone, but in reality is due to spasm of the internal

sphincter muscle. A small calculus may become impacted in the prostatic urethra during the act of micturition, causing sudden interruption of the stream accompanied by severe pain. In one case under my care the patient stated that such interruption was so frequent that he had formed the habit of passing urine whilst on his hands and knees which he had found prevented the occurrence of impaction.

The patient may also give a history of the passage of "gravel", but this should not be too readily relied upon unless he produces definite small calculi, as the so-called gravel may be merely pieces of phosphatic debris which may be present with chronic cystitis or be limpet-shaped pieces encrusted upon a vesical carcinoma.

The penile pain and hæmaturia caused by a calculus are due to the actual contact of the stone with the trigonal area of the bladder and both symptoms may be absent when urinary obstruction is present. Thus with an enlarged prostate or with urethral stricture there may be some residual urine remaining in the bladder following micturition which surrounds the calculus. With prostatic enlargement, frequency of micturition is present during both day and night and if any pain is present, it is felt as an aching in the perineum or rectum.

In cases in which infection of the bladder has occurred the symptoms will be aggravated and at the same time altered by the cystitis. The frequency is not influenced by movement but will be increased during both day and night and the pain will be not only more severe, but will occur before as well as after micturition. The urine becomes loaded with pus and is frequently very offensive.

The examination of a patient with vesical calculus is mainly instrumental. It is only rarely that a stone in the bladder can be felt. In children a vesical calculus may be felt upon bimanual rectal examination under an anæsthetic and in the female a calculus may be palpated on vaginal examination, especially if it occupies a cystocele. Vesical calculus is, however, comparatively uncommon in women, occurring only in about 5 per cent. of cases. Occasionally large calculi in the bladder may be palpable or again may be felt if occupying a diverticulum on one side of the bladder base.

Examination of the urine is not distinctive. In the absence of infection, the urine may contain red blood discs and numerous vesical epithelial cells, together with urinary crystals. With infection numerous pus cells and micro-organisms are present.

Sounding the bladder for stone has practically been replaced by cystoscopy and radiography and is now seldom performed. It may be used where the more recent methods are not available, but is much less exact. The sound should be passed with every aseptic precaution and only after the bladder has been washed out and filled with about four ounces of sterile fluid. Each part of the bladder is systematically explored by rotating the beak of the instrument, when, if a calculus is present, either a distant click is heard and felt or a sensation of grating of the metal on the surface of the stone is felt. Certain fallacies in this method of examination must be remembered. The stone may be small and may be entirely missed, may be behind the intravesical projection of an enlarged prostate or may be in a diverticulum. On the other hand, the surgeon may believe that he has felt a calculus when none is present. A vesical carcinoma covered with phosphatic caps may give a sensation of grating or the trabeculation of a hypertrophied

bladder wall may be mistaken for stone. In an old-standing case of vesical infection the surface of the stone may be so covered by thick muco-pus that neither the grating nor the characteristic click is felt.

Cystoscopy provides the most satisfactory evidence of vesical calculi. First it may reveal a calculus that not only a sound may miss, but which may not be evident on radiographic examination. It will also show whether multiple calculi are present, will show the condition of the vesical wall and whether some other condition such as an enlarged prostate, a vesical diverticulum or a vesical growth is present. On more than one occasion I have found a vesical growth to be present in addition to a calculus and which determined a suprapubic operation instead of removing the calculus by crushing. A calculus in a diverticulum may be seen through the orifice if it is large and nearly fills the cavity of the sac; sometimes the calculus is partly in the diverticulum and partly in the bladder, when it will appear to be fixed in one side of the bladder rather than in the usual situation in the mid post-trigonal area. Cystoscopy also will show the nature of the stone; an oxalate calculus shows a dark rough, uneven surface, one of urates a comparatively smooth, pale, yellow appearance, whilst one covered with phosphates presents a white surface. Cystoscopic examination may be difficult when severe infection is present owing to severe irritability of the bladder or to the amount of muco-pus contained in it. Practically the only fallacy likely to arise in these cases is that of a vesical carcinoma which in the presence of infection has become encrusted with phosphatic material. In these cases, the mass appears to be fixed on one side of the bladder, but usually some area of growth will be visible.

Finally, cystoscopy will show that the apparent calculus is formed upon a foreign body introduced into the bladder, portions of which may be seen projecting from the surface of the calculus. Thus in a female, a calculus may form around an unabsorbable suture used in some previous vesical operation or after a hysterectomy. It has also been seen around a hairpin or piece of wood ("slippery elm") used in an attempt to produce abortion. In the male patient a broken piece of catheter has been found thickly covered with phosphatic material, whilst I have seen a glass tube which formerly contained hypodermic tablets, a small wax candle from a Christmas tree and a grain of barley in the bladder.

Radiographic Examination cannot be relied upon in the diagnosis of vesical calculus to the same extent as in the diagnosis of renal or ureteric calculi. This is due to the fact that vesical calculi are frequently formed of uric acid which only possess a density to X-rays about the same as the soft tissues of the body and may therefore not show a shadow in the pelvis. It is therefore safer to examine any patient who has symptoms of vesical calculus with the cystoscope rather than to rely upon a negative report from a radiologist. An oxalate or phosphatic calculus will show a fairly dense shadow.

The shadow of a vesical calculus is usually well defined and lies in the middle line with its longer axis horizontal. (Fig. 15.) A stone in a diverticulum may

appear to one side of the middle line and if it is partly contained in the diverticulum and partly in the bladder it may appear to be of dumb-bell shape. A small shadow with oblique axis to one side of the middle line is more likely to be that of a calculus in the lower ureter and the diagnosis will be made on cystoscopic examination.

It is seldom that a shadow seen in the pelvis on radiographic examination will cause difficulty in diagnosis. Faecal masses in the rectum may give a rounded shadow, but are of uneven density and of irregular, ill-defined outline. A calcified fibroid tumour of the uterus or areas of calcification in an ovarian dermoid may show shadows but the diagnosis will be made on vaginal examination.

The differential diagnosis of a vesical stone from other conditions affecting the urinary organs should not be difficult when a complete urological examination has been carried out. In the absence of a cystoscopic or radiological examination, however, the practitioner may have to form an opinion on the data presented to him. A **vesical papilloma** or a **villous-covered carcinoma** will give a history of intermittent attacks of profuse hæmaturia unaccompanied by pain unless clots are formed in the bladder. A vesical **epithelioma** may, however, give rise to increased frequency of micturition, pain, and terminal hæmaturia, but the frequency is present during the night as well as by day, progressively increasing and is not influenced by movement. Cystoscopic examination will readily show the nature of the disease.

A **calculus in the lower end of the ureter** may present symptoms very similar to those of a vesical calculus, and there may be a preceding history of renal colic with either condition. With a ureteric calculus there is often pain or aching over the external abdominal ring as well as penile pain on micturition and in addition there may be aching in the posterior renal area from increased intrarenal tension. A ureteric calculus will show an oval or elongated shadow with a vertical or oblique long axis on one side of the middle line, whereas a vesical stone lies in the middle line in a horizontal axis. Cystoscopic examination will show a vesical stone to be lying free on the base of the bladder, or if in the lower ureter there will most likely be characteristic oedema and swelling around the ureteric orifice.

A patient the subject of an **enlarged prostate** complains of gradually increasing desire to micturate, both during the day and the night with some hesitation in commencing micturition, but he is free from pain during the act. His symptoms are not aggravated by movement and if hæmaturia occurs it is usually fairly profuse and intermittent. It is, however, common for a patient with an enlarged prostate to harbour a calculus in his bladder in the post-prostatic pouch, especially when infection co-exists, but the symptoms of calculus are overshadowed by the prostatic trouble by reason of the residual urine left in the bladder after micturition.

Urinary tuberculosis occurs usually in young adults and is characterized by increased frequency of micturition, pain in the penis or vulva, with constant slight terminal hæmaturia and pyuria. The presence of an old tuberculous lesion

in a joint, etc., the age of the patient, and the finding of tubercle bacilli in the urine will point to the disease. In many cases a thickened ureter may be felt *per vaginam* or tuberculous foci may be felt in the epididymis or seminal vesicle. Sounding the bladder should never be carried out in a case suspicious of tuberculosis, but a careful cystoscopic examination may show tuberculous lesions in the bladder or changes about the ureteric orifice.

Bilharzial infection of the bladder may be mistaken for stone, as it gives rise to vesical irritability, pain and terminal hæmaturia. A previous residence in infected areas, as in Egypt or South Africa, may help, but the finding of the typical ova in the urinary deposit will give the diagnosis. Bilharzial infection may be accompanied by calculus.

4. PROSTATIC CALCULUS.

Calculi may be found in the glandular substance of the prostate and should be distinguished from calculi which have passed from the bladder into the prostatic urethra and from calculi which may be formed in a pouch in the prostatic urethra.

True prostatic calculi occur in middle life, are usually multiple and may attain considerable size, forming a mass in one or both lobes of the prostate. When multiple they are frequently faceted and give a sense of crepitation to the finger on rectal examination. The symptoms of prostatic calculi are often indefinite. There is some increased frequency of micturition during both day and night, with hesitation or difficulty in commencing to void, leading occasionally to acute retention. Pain is usually present, either in the perineum or rectum and is frequently felt as a constant aching at the base of the sacrum. Examination of the urine may show no abnormality unless the cavity containing the calculi has opened into the prostatic urethra, when pus or blood may be present. Similarly, a catheter or sound will not feel any grating when passed into the prostatic urethra unless the cavity communicates with the latter, but difficulty may be experienced in passing any instrument into the bladder owing to alteration in the normal line of the canal by pressure of the calculi. Residual urine is usually present.

On rectal examination the prostate is felt to be enlarged, but the surface is not uniform. There may be a localized hard nodule in one or both lobes or the whole gland may appear as a hard mass which may give a sense of crepitation on pressure. The gland, however, is movable in the pelvis.

Radiographic examination will show a shadow which, if the tube is centred over the pelvis, will appear behind the pubes, either in the middle line or to one side of the symphysis. The shadow is usually irregular and of varying density as the calculi are multiple.

The *diagnosis of prostatic calculi* should not be difficult. A hard nodule felt in the prostate *per rectum* may be thought to be due to **carcinoma**, but in the latter the gland is fixed in the pelvis and a band of infiltration may often be felt

passing upwards and outwards from the upper aspect of the gland. There will be no crepitation with carcinoma and no shadow will be visible on a radiogram.

A **tuberculous nodule** in the prostate is seldom so firm as a calculus and if tuberculous disease is present there will usually be evidence of similar disease in the vesicles, the testes or in the urinary organs. Again radiography will assist.

Chronic prostatitis may cause symptoms similar to prostatic calculi, usually aching pain with increased frequency of micturition, and on rectal examination a localized area of inflammatory thickening may be felt in the prostate—but rarely so defined as in calculus. No shadow will be seen on a radiogram.

5. URETHRAL CALCULI.

These are nearly always secondary calculi which have been passed down from the kidney or bladder and have become arrested in the urethra. They may, however, be formed in the urethra in a pouch most frequently when infection is present behind a stricture and these cases are frequently associated with a perineal urinary fistula.

Secondary calculi in the urethra may be present at any age. It is not uncommon in young children for micturition to become suddenly arrested with severe urethral pain when a small calculus has become impacted in the urethra, most frequently in the prostatic area or in the fossa navicularis. In adults a stone may be passed down after an attack of renal colic into the bladder and then after an interval pass into the urethra.

A stone formed in the urethra behind a stricture with infection will be increased in size from phosphatic deposition mainly on the vesical aspect. If in the prostatic urethra the portion towards the bladder becomes flattened, and a stone of mushroom-form is produced. It may form a cast of the urethra, the prostatic portion being joined to the larger cast of the bulbous urethra by an area constricted by the compressor urethræ muscle. These calculi are practically always formed behind a stricture and are accompanied by difficulty in micturition (poor, feeble stream of urine) and by a purulent urethral discharge. Frequently a urinary fistula is present.

The diagnosis presents no difficulty. The sudden cessation of the stream of urine during micturition accompanied by acute pain is fairly diagnostic, the only condition resembling it being the very rare instance of a papillomatous growth of the bladder being engaged and impacted in the internal urethral orifice. In such a case there will be a history of previous intermittent hæmaturia.

A calculus may be felt on palpation in the perineum or along the course of the urethra and may be felt on passing a bougie along the canal or actually visualized on urethroscopy. Radiographic examination in the case of urethral stone will cast a shadow in the middle line but below the pubic symphysis. The shadow is usually more or less vertical in the long axis.