A Paper
ONTHE DIAGNOSIS OF URETERIC
CALCULI.*

BY

ANDREW FULLERTON, C.B., C.M.G., M.D., F.R.C.S.I.,
Professor of Surgery, Queen's University, Belfast; Surgeon,
Royal Victoria Hospital, Belfast.

In opening this discussion I shall limit myself to an account of my own personal experience, confident that omissions in the presentation of the subject will be dealt with by others.

COMPOSITION OF URETERIC CALCULI.

I have made a rough analysis of 35 ureteric calculi passed by patients or removed by operation. In no fewer than 29 of these—that is, in 80 per cent.—the main constituent was calcium oxalate. In 5 cases phosphates predominated, and in one case only was there a preponderance of uric acid. If this experience is corroborated by others, the accounts given in the textbooks, which emphasize uric acid or urates as the chief constituent of renal and ureteric calculi, require modification.

CHARACTER AND EFFECTS.

Ureteric calculi vary, of course, in size, shape, and colour. A very common type is small in size, irregular in shape and outline, with sharp edges, greyish or brown in colour, and often crystalline in appearance. The sharp, almost knife-like, projections of these little calculi lacerate the delicate mucous membrane of the ureter in their passage, and the calculi are liable to be held up at the points where the ureter narrows or changes its direction. Hence they are frequently arrested at the outlet of the renal pelvis, at the vesical end of the ureter, and, much less frequently in my experience, at the brim of the pelvis. It takes very little trauma to draw blood from the mucous membrane of the ureter. The passage of a smooth ureteric catheter, even with the greatest care, is liable to be followed by slight haemorrhage, and if the catheter is retained for any length of time the specimen obtained from the ureter may be deeply blood-stained. It is easy to account, therefore, for two, at least, of the signs and symptoms of ureteric calculus—namely, haemorrhage and pain. Haemorrhage is caused by laceration of the mucous membrane and pain by the irritation and consequent increased peristalsis of the ureter. Another cause of pain is the increased tension produced in the renal pelvis when the calculus causes a partial block of the ureter. A ureteric calculus rarely causes complete obstruction of the ureter. The urine tends to find its way past even a large calculus, and may actually groove or tunnel it. The absence of an efflux from the affected side does not necessarily mean a mechanical block; it may be due to a reflex anuria. I have only once seen a complete mechanical block, and this occurred in a patient who had suffered from a tuberculous kidney for many years. The lower end of the ureter on the affected side was occupied by a large phosphatic calculus which had mushroomed into the bladder.

There is another remarkable phenomenon produced by the presence of these irregular foreign bodies in the ureter, and that is reflex polyuria on the affected side. Twenty years ago, when the Association met in Sheffield, at a discussion on the "Indications for nephrotomy and nephrectomy" I brought forward the subject of unilateral diuresis, and gave several examples. Since then I have made some hundreds of observations, and the views then expressed as to the importance of this sign in diagnosis have been abundantly confirmed. Let me give a recent example.

A gentleman, aged 45, about two months before examination, began to complain of attacks of pain in the left side, radiating downwards. The attacks were associated with vomiting and, on several occasions, with haematuria. When the urine was examined, however, on August 10th, 1927, it was found to be chemically and microscopically free from abnormal constituents.

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except for a number of calcium oxalate crystals. On ureteric catheterization the flow on the affected side was found to be rapid and copious, and the specimen had a specific gravity of 1005. On the sound side the flow was very scanty and the specific gravity of the specimen was 1015. A radiogram showed a small shadow, possibly due to a calculus, in the position of the lower end of the left ureter. About eighteen days after cystoscopy he had a severe attack of pain, and three days later passed a small irregular calculus a little larger than a hemp seed. A week later cystoscopy was again carried out, and the specific gravity was now 1015 on both sides and the quantity of urine equal on the two sides.

Note that in this case the urine at the time of examination was perfectly normal, and the only unequivocal sign incriminating the kidney was a definite polyuria on the affected side, which passed off when the calculus was got rid of.

Another case, in which a more detailed examination of the urine was made, and which has already been published,¹ is the following.

A man, aged 34, was seized ten days before examination with severe pain in the left loin, radiating to the umbilicus. This passed off, to recur again in a very severe form several times. Cystoscopy was carried out shortly after one of these attacks, and catheters were passed into the ureters. The catheter on the left side encountered an obstruction a short distance up, which was negotiated with a little difficulty. The flow from this side was vigorous and free, while that from the right was sluggish and scanty. The specimen obtained from the left side had a specific gravity of 1010, contained 0.304 per cent. of chlorides and 0.48 per cent. of urea, and was much greater in quantity than that obtained from the right side. That from the right side had a specific gravity of 1030, contained 0.836 per cent. of chlorides and 2.16 per cent. of urea, and was discharged in drops, depositing urates on cooling. A radiogram showed a small shadow about the size of a pin's head at the lower end of the left ureter. On the third day after cystoscopy a small spiculated calculus was passed per urethram and all pain ceased. Four and a half days later his ureters were again catheterized with the following result. There was now no demonstrable difference in the rate of flow, and the specific gravity was 1015 on both sides. The specimen from the left side showed 1.45 per cent. of chlorides and 0.84 per cent. of urea, while that from the right showed 1.40 per cent. of chlorides and 0.78 per cent. of urea. In other words, the specimens on the two sides were almost identical. On both occasions there were a few red blood corpuscles in the specimen from the left side, but there was no pus in either specimen.

In these cases of unilateral diuresis the jets on the affected side follow one another in more rapid succession than on the opposite side, and the quantity in each jet is larger in amount. There may also be some irregularity in the rhythm on the affected side. The specific gravity is estimated by glass beads, and the quantity necessary is about 4 to 5 c.cm. Smaller quantities will suffice, but are more troublesome to work with.

For the purposes of this discussion I have looked up the notes of 50 undoubted cases of ureteric calculus occurring in my own practice. All except two of these were proved or presumed to be in the lower ureter, and all true renal calculi were excluded. In 20 of these the investigation just mentioned was carried out, and in no fewer than 14, or 70 per cent., an easily demonstrable diuresis, with diminished specific gravity of the specimen, was present on the affected side. In 3 cases no difference could be detected between the two sides, and in 3 anuria, probably reflex in character, was present. In one of the latter cases, on a second examination, though the calculus was still present, an abundant flow of dilute urine was obtained from the affected side. The calculus was subsequently removed by operation. When a calculus has been present for some time in a ureter hydronephrosis may result, and it is desirable to know if the dilute urine which is secreted by a hydronephrotic kidney differs in any way from that due to diuresis. My colleague Dr. Mayrs, who has been associated with me in this work, will deal with this point, and will give the results of his examination of the urine in a number of cases.

While much has been written on calculous anuria very little has been said on the occurrence of unilateral diuresis from whatever cause produced. The explanation of both phenomena is afforded by a study of the nerve supply to the kidney and its influence on the blood flow. Through the splanchnic nerves the kidney receives vaso-constrictor and vaso-dilator fibres. The stimulus of a calculus may cause vaso-constriction and reduction or cessation of the secretion of urine on that side, due to diminished blood flow through the glomeruli. On the other hand, it may cause vaso-dilatation, increased blood flow, and diuresis.

The latter is the more common occurrence. Cushny, in his work on *The Secretion of Urine*, discusses "pressure diuresis" seen in animals where one ureter is slightly obstructed, and states that it is almost certainly due to reflex vaso-dilatation. He suggests that a slight stimulus arouses a dilator effect, while a stronger one, such as the pain of a calculus, sets the more powerful constrictor in action, and thus leads to anuria. My observations go to show, however, that even with severe pain renal or ureteric calculus is much more commonly associated with diuresis than with anuria.

SIGNS AND SYMPTOMS OF URETERIC CALCULI.

Pain.

The chief symptom of a calculus in the ureter is pain, and it may be the only symptom present. Papin and Ambard² give some interesting facts bearing on renal pain to which a short reference may be made. The kidney receives its chief nerve supply from the splanchnic nerves through the renal plexus, and a branch from the first lumbar ganglion. The nerves to the kidney are, with few exceptions, non-medullated, while those

correspond in part to the kidney; the eleventh and twelfth dorsal and the first lumbar correspond to the pelvis and ureters. Certain reflex phenomena, such as nausea, vomiting, and pallor, with cold sweats, unassociated with disturbance of pulse or respiration, commonly accompany pain due to distension of the renal pelvis. Papin and Ambard are of opinion that renal pain is usually, as a matter of fact, "pyelic," and that obstruction of the ureter declares itself by renal colic due to distension of the pelvis. It would seem reasonable to assume, however, that increased peristalsis of the ureter, the result of an irritant such as a calculus, is a factor in the production of the pain known as renal colic.

The pain due to the passage or the arrest of a ureteric calculus cannot, I think, be distinguished from that due to a renal calculus lodged in the pelvis of the kidney. I have gone over the notes of my cases of ureteric calculus and compared them with those of known cases of renal calculus, and have come to the conclusion that the site and character of the pain may give no clue whatever to the size or position of the calculus. It is further evident from these notes that a precisely similar calculus may give rise in one

FIG. 1.—Ureteric calculus occupying a frequent position—that is, opposite the ischial spine.

distributed to the pelvis and ureter are for the most part medullated. The cells met with in the ganglia of the renal plexus are of the sympathetic type. It appears probable that renal pain issues from the sympathetic, the cells of which oppose an obstacle to impressions only overcome when these are of a violent nature. It is probable that painful sensations in the sympathetic system are really only perceived on quitting that system and gaining, by way of the rami communicantes, the posterior roots of the cord and through them the cerebro-spinal centres. Hence it is that pain is often reflected along the course of nerves connected with the corresponding rami communicantes.

Compared with the kidney, the pelvis and ureters are highly sensitive. Distension of the pelvis is very definitely painful. If more than 3 to 7 c.cm. of fluid are injected into a renal pelvis, pain resembling renal colic is, as a rule, provoked, and may at once be relieved by drawing off the fluid injected. The pain commences, as a rule, in the costo-lumbar region, or in the subcostal region in the anterior axillary line. Tender points can be demonstrated by touch in the costo-lumbar, subcostal, para-umbilical, and iliac regions. These areas are those to which pain is referred by the cerebro-spinal nerves from impressions received by the sympathetic. Pain may be referred along the course of the nerves of the lumbar plexus towards the thigh, the testicle or labia majora, or to the renal region of the opposite side. Zones of cutaneous hyperaesthesia may be demonstrated by stroking, pricking, or pinching the skin. The tenth, eleventh, and twelfth dorsal segments

FIG. 2.—Ureteric catheter arrested by calculus.

patient to the merest discomfort, while in another the pain may be of the severest character, radiating to the utmost terminations of the peripheral nerves. Again, a calculus may remain in the ureter for weeks or months and only periodically give evidence of its presence.

The pain in the cases that have come under my notice has varied very much in position, character, and severity. In a few vague discomfort only was complained of, referred to the back, to the side, or to the iliac region. In others attacks of typical renal colic occurred, the pain commencing in the costo-vertebral angle and radiating downwards to the iliac region, the testis or vulva, the hip, the thigh, the rectum, the knee, or even to the foot. In some cases it was referred to the umbilicus or to the opposite side. In other cases the pain commenced in the iliac region and radiated upwards to the back and downwards to the lower part of the body. In others again the pain was stationary in the back or side or in the iliac region. In a case of renal calculus, not included in this series, the patient, a woman aged 30, yelled with pain in the knee. In another case of renal calculus the pain started in the region of the left kidney and radiated to the shoulder and the back of the head. In a certain proportion of cases a note was made of rigidity, or at least of increased tone of the abdominal muscles on the affected side, but the board-like rigidity of peritonitis was never present. Tenderness over the kidney and ureters was frequently found. The pain when severe was often accompanied by vomiting, pallor, and cold sweats.

The pain may be of momentary duration or may last

for hours. It may begin gradually or suddenly and cease in the same way. It may occur in attacks with long or short intervals of complete freedom or it may be continuous. It may come on in the middle of the night while the patient is in bed or it may occur while he is walking about. In many cases it is aggravated by exercise. Hot fomentations frequently relieve it. Its character also varies, being described as an ache, a sense of discomfort, a gnawing or burning sensation, a bursting feeling or a feeling of fullness, a stab, a tearing or cutting sensation, and so on. It is generally easily distinguishable from the more familiar pain of intestinal colic.

I have been struck, in reading the notes, how often pain in the iliac fossa, either fixed or radiating, was complained of. Given a patient with a pain in the right iliac fossa, vomiting, and some tenderness and rigidity on that side, and it is easy to see how the case may be

FIG. 3.—Calculi in lower part of ureter and two in lower part of a hydronephrotic sac. Calculi are also present in the opposite kidney.

mistaken for one of appendicitis. The easy-going diagnosis of chronic appendicitis is responsible for more errors than one cares to contemplate with equanimity. Frequently patients state that they have been operated on for appendicitis without relief. Before a surgeon commits himself to a diagnosis of chronic appendicitis a complete chemical and microscopical examination of the urine should be made. If still in doubt he may be saved from the chagrin of an unsuccessful operation by a cystoscopic examination and the discovery of significant changes at the ureteric orifice on the affected side, or a unilateral diuresis. Should an appendix at operation be found to be healthy, or at least not sufficiently diseased to account for the patient's symptoms, the abdomen ought not to be closed without a detailed examination, and in this the ureter should be included. The most frequent place in the lower ureter for a calculus to be arrested is at or near its entrance into the bladder, and this portion can be explored in a doubtful case by detaching the peritoneum from the pelvic wall so as to expose the ureter extraperitoneally. A catheter in the ureter from the bladder will much facilitate this exploration. If a calculus be found it can be removed and an abortive operation averted.

Frequency of Micturition.

It is generally believed that when a ureteric calculus approaches the bladder its arrival is heralded by frequency of micturition and straining. This symptom, however, may be entirely absent. I removed a calculus about the

size of a date stone from the lower end of the right ureter in a woman aged 21 who did not have any frequency of micturition; also a large calculus, 3 inches long and 1 inch thick, from the vesical end of the left ureter in a boy aged 18½ years who had no frequency and no dysuria. In another case, that of a male aged 43, the calculus was actually seen by cystoscope in the orifice of the left ureter, and yet there was no complaint of frequency or dysuria. On the other hand, I have seen many cases of calculus lodged in the renal pelvis in which frequency of micturition was present. All this tends to demonstrate how difficult it is by symptoms alone to locate a urinary calculus.

Rectal Tenesmus.

One or two of my patients with a calculus arrested at the entrance of the ureter into the bladder have complained of rectal tenesmus.

Inflammatory Signs.

The presence of a calculus in the kidney or ureter is liable to give rise to inflammatory changes, and infection by micro-organisms, generally the *Bacillus coli*, is not infrequent. In addition to pyelitis, ureteritis and peri-

FIG. 4.—Showing relation of phleboliths to bladder. The cystogram shows also a filling defect due to a tumour.

ureteritis at the point of arrest, leading to much thickening, may occur. These changes are frequently associated with a rise of temperature and an increase in the pulse rate. A leucocytosis may be revealed on blood examination, and pus and micro-organisms will be found in the urine.

The Presence of Abnormal Constituents in the Urine.

Haematuria may be the first symptom of a renal or ureteric calculus, and in rare cases the only symptom. I have pointed out that a calculus may be lodged in the ureter and yet the urine may fail to show any microscopical or chemical abnormality. In a case of suspected ureteric calculus, however, it is very unlikely that this state of affairs will continue. Frequent examinations should be made, especially for blood, which may, perhaps, be detected only by the microscope. The specimen for this examination should be taken without any instrumentation. A catheter, no matter how carefully passed, may draw microscopical blood and obscure the diagnosis. The meatus in both sexes may be carefully cleansed and contamination avoided by measures that will readily suggest themselves. The presence of microscopical blood is of more importance in diagnosis than a few pus cells, having regard to the fact that the latter are so frequently found in the urethra. Pus and albumin in the urine are, of course, confirmatory tests, and should always be looked for. The presence of crystals of triple phosphate, calcium oxalate, or uric acid is so frequent as to be of only secondary value in diagnosis, unless in great abundance.

EXAMINATION OF THE PATIENT.

The patient will be examined for tenderness and swelling of the kidney, for tenderness along the course of the ureter, for tenderness of the testicle on the affected side without other obvious cause, often with a negative result; also for the areas of hyperaesthesia to which reference has already been made. Rigidity of the abdominal muscles is more suggestive of an intra-abdominal lesion, but, as stated above, it may be present with renal or ureteric calculus. Besides appendicitis, acute and chronic, many other intra-abdominal conditions may give rise to symptoms more or less resembling those of ureteric calculus. Such are cholecystitis, gall-stones, gastric and duodenal ulcer, intestinal obstruction, colitis, tuberculosis and other infections of the abdominal lymphatic glands, and affections of the ovary and tubes. The surgeon's examination will include, therefore, a wide survey of the abdominal organs. Other affections of the kidney itself may give rise to symptoms indistinguishable from those of renal or ureteric calculus. Hydronephrosis, for instance, may give rise to typical renal colic as severe as that caused by a calculus. Renal colic may be present also in tuberculous and other infections of the kidney, malignant growths, hydatid disease, haematuria with clots, etc., and is due to the passage of clots or portions of growth or cysts down the ureter. In fact, any lesion that narrows or obstructs the ureter in any part of its course may give the symptoms of stone in the ureter, and these can be eliminated for the most part by cystoscopy, ureteric catheterization, ureterography, and pyelography.

A rectal or vaginal examination is a most important part of the examination of a suspected case of ureteric calculus. The stone can frequently be felt in the lower end of the ureter through the rectal or vaginal wall, or the ureter may be felt greatly thickened, as was found in the following cases. In a male, aged 22, with symptoms of renal calculus with vesical irritability I was able to feel through the rectal wall what I took to be a thickening of the lower end of the right ureter. The swelling was about the size of an almond. X rays showed a well-defined ovoid shadow in this position. Operation disclosed a segment of ureter about three times the normal size, with thick walls, enclosing a calculus about the size of a melon seed. In a girl, aged 21, with pain in the right iliac fossa radiating to the back and without vesical symptoms, the lower end of the right ureter could be felt greatly thickened per vaginam. At operation, the ureter just proximal to the bladder was found thickened to about the size of a plum stone, and a calculus about the size of a date stone was liberated from its interior. A thickened ureter, therefore, as felt per vaginam or per rectum, may be an important sign of an impacted ureteric calculus.

X-RAY EXAMINATION.

Examination by x rays is one of the most valuable means of diagnosis at our disposal, but many are the pitfalls. A discussion of this subject alone would occupy all the time at my disposal.

The shadow of a calculus varies according to its atomic weight and its density. Those composed of calcium oxalate give the deepest shadows; phosphatic stones come next, while uric acid calculi may give no shadow whatever (Heyerdahl). Of the various opaque bodies likely to be mistaken for calculi in the urinary tract the most important from their position, size, and shape are the phleboliths, the frequency of which has only been demonstrated since the use of x rays for diagnosis has become general (see Fig. 4). Phleboliths are round or oval in shape, small and uniform in size, often bilateral, and situated, as a rule, below the great sciatic notch and lateral to the line of the ureter (Culligan). If multiple, they are usually disposed in a linear fashion rather than in groups. The shadow of a phlebolith resembles closely that of a ureteric calculus, but the latter is more apt to be irregular in shape and outline. A very common situation for the shadow of a ureteric calculus is opposite to the ischial spine (see Fig. 1.)

Calcified glands, following on tuberculous infection, are very common. The shadows given by these are generally larger, more irregular in shape, and less dense than those of phleboliths. Some of the shadows may show areas of

greater density at the periphery in the form of rings or crescents. Calcified glands are collected into groups rather than rows, but isolated ones occur and may be difficult to distinguish from ureteric calculi. Calcification of the pelvic ligaments and muscles, faecal excretions or foreign bodies in the intestine and in the appendix, and retained foreign bodies, such as the missiles of war, have all been mistaken for urinary calculi.

To establish a diagnosis an ordinary radiogram is first taken, and if suspicious shadows appear the exact relationship to the kidney, ureter, and bladder is defined by an opaque catheter (see Fig. 2), or by a ureterogram, a pyelogram, or a cystogram. The value of this examination is greatly enhanced by stereoscopic radiography. It is obvious that the opaque catheter, for instance, may pass across the shadow of a body which is in front of or behind it. The exact relationship may be determined by knowing the shift of the x-ray tube and its distance from the plate in taking stereoscopic radiograms. Accurate calculation can then be made of how far a body giving a shadow is removed from the ureter or kidney. During the war this method proved invaluable, and surprisingly accurate localization of foreign bodies relative to the kidney and ureter was obtained in many cases. The value of a ureterogram or pyelogram when a shadow does not coincide exactly with the line of the opaque catheter is obvious. For instance, a ureter may be dilated and the shadow, though not touching that of the opaque catheter, may be seen to be covered by the shadow of the dilated ureter. Very striking results are sometimes seen by pyelography, as, for instance, in one of my cases in which, in addition to three shadows in the line of the lower ureter, two small oval shadows were seen far removed from the line of the upper ureter. Their significance was shown by pyelography, which demonstrated a huge hydronephrosis with two shadows at its lower limit. The diagnosis was obviously a couple of calculi which had gravitated to the bottom of a hydronephrotic sac (see Fig. 3).

I have laid some stress on the possibility of mistaking a case of ureteric calculus for one of appendicitis, but I have a specimen which shows how a diseased appendix may be mistaken for a ureteric calculus. In this case the x-ray report strongly suggested calculi in the ureter, and to make the diagnosis more difficult there was a slight difference in the urine from the two sides, that on the right having a specific gravity of 1015 as compared with 1020 on the left. In addition, the ureteric catheter encountered some opposition a few inches up on the right side. The urine on the affected side, however, did not contain pus, which would almost certainly have been the case if calculi of the size suggested by the shadows seen in the radiogram had been present in the ureter. The appendix was therefore explored, and found to contain one large and one small concretion of the correct size and shape. The proximity of the appendix to the ureter in this case may have caused some obstruction to the passage of the catheter, hence the difficulty in diagnosis.

It is not uncommon to find calcified glands in the neighbourhood of the kidney or ureter, but it is not generally known, I think, that calcified areas may be present in the perirenal or peri-ureteric fat. I have several specimens in which this condition was found, and will mention one example in which the x-ray report stated that there were four shadows in the renal region—one circular and three irregular in shape—probably calculi. When the kidney was explored I could only find one round-shaped calculus in the pelvis. After searching in vain for the other three I found in the perirenal fat three irregular calcified masses corresponding in size and shape to the x-ray shadows. Here an opaque ureteric catheter and stereoscopic radiograms would have been of great assistance.

In passing the ureteric catheter it may be felt to hitch against what appears to be an obstruction in the ureter. With a little manipulation it may or may not be made to pass on. This difficulty in passing the catheter is so frequently found in cases with no abnormality whatever in the ureter that it cannot be considered of any diagnostic importance. The tip of the catheter may catch, for instance, in a fold of the mucous membrane or be arrested by spasm. A ureteric calculus, even one of considerable

size, may, on the other hand, offer no obstacle to the passage of the catheter, and it may not even be felt as an obstruction.

CYSTOSCOPIC APPEARANCES.

Looking over my case sheets I find that, in addition to the alterations in the rate of secretion and in the rhythm of the jets to which I have already referred, and the presence of blood or pus in the efflux, I have notes of certain changes at the ureteric orifice on the affected side as seen by the cystoscope; the following description is based on these notes. There may be no apparent departure from the normal, the orifice remaining slit-like and free from surrounding vascularity or oedema. Thus there were no obvious changes in three cases, in each of which a calculus was subsequently removed from the ureter, just proximal to its entrance into the bladder wall. In 20 out of the 50 cases, however, definite changes were specially described. These consisted of the following:

Some departure from the slit-like shape of the orifice, which had become sinuous, oval, circular, or irregular in shape. In some cases the orifice was more patulous than normal. In a few, the only noticeable change was increased vascularity, without swelling, round the orifice. In the large majority, however, there was a good deal of redness and oedema at and around the orifice. The opening of the ureter in some cases was completely obscured and perched on the top of a little mound or hillock of oedematous mucous membrane, and was only discovered by probing about with the tip of the catheter. The chief sign was, therefore, alteration of the shape of the orifice,

associated with oedema at the spot and for some distance around. The orifice, if not obscured, often appeared like a dimple in the centre of a raised area of mucous membrane. In a few cases oedematous tags resembling minute papillomata were seen surrounding the opening. Occasionally flecks of lymph were seen on the lips or shreds of purulent material projecting from the orifice.

A very characteristic sign was the presence of small haemorrhagic points and splashes around the orifice, extending in some cases along the interureteric bar as well as laterally. In four cases the calculus was actually seen in the depths of the orifice or about to drop into the bladder. In five cases, examined after an attack of pain, the calculus was seen lying at the base of the bladder.

I have thus had the opportunity of observing what may be termed the birth of the calculus. The ureteric orifice has more than a fancied resemblance to the vulva, and it is fascinating to watch the calculus, like a foetal head, advancing and receding as in the act of parturition. Like my friends the obstetricians I have "put on forceps" to assist nature, and in a few cases I have even performed a miniature cephalotripsy. When the dystocia has been insurmountable I have, like them, resorted to a form of Caesarean section: and finally, again like them, I have been amply rewarded for my trouble by the effusive thanks accorded to me when I have presented to the author of its being the fruit of his loins.

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ENCEPHALO-MYELITIS IN VIRUS DISEASES AND EXANTHEMATA.*

BY

HUBERT M. TURNBULL, D.M.,

Director of the Bernhard Baron Institute of Pathology, the London Hospital.

THE HISTOLOGY OF POST-VACCINAL ENCEPHALITIS.

I UNDERSTAND that the primary subject of the discussion is the nature of encephalo-myelitis following vaccination. It is no longer necessary to argue that an encephalo-myelitis is sometimes a complication of vaccination. The exact cause of the encephalo-myelitis need alone be discussed.

Is the encephalitis caused by the virus of vaccination lymph, or by some other infection introduced at vaccination, or does the vaccinal virus excite some latent infection? If the encephalo-myelitis is the result of an infection introduced at vaccination or excited by the vaccination, are the resulting histological changes due to the action of the introduced or excited infection alone or to the combined action or the interaction of such an infective agent and the vaccinal virus?

In finding an answer to these questions a great many methods are of service; one of these is comparative histology. To that method my remarks will be confined.

The histological changes in post-vaccinal encephalitis have been remarkably uniform in all cases which I have seen or of which I have read a description. The case of Paul (1928) may be an exception; I have not had access to the description of this actual case, but only to that of the example of severe poliomyelitis in which, he says, the changes were astonishingly similar. The description of seven brains and cords given by Turnbull and McIntosh (1926) amplified that of two brains by Bastiaanse (1925), and has in turn been confirmed, amplified, and in one point corrected by the descriptions of three brains and cords by Perdrau (1928), of one brain and cord and one segment of brain by Schürmann (1928), and of three brains by Lucksch (1927) in his later paper. I have subjected the formaldehyde-paraffin material from the first four of our seven cases to other stains, particularly Victoria blue and Mallory's phosphotungstic haematoxylin; with the

latter not only can the fibroglia and myelin be stained, but the bodies of the proliferated glial cells are sharply defined. A further case was obtained by Dr. Woods during my holiday in September, 1927: a male of three months, who became ill on the tenth day after vaccination and died on the twenty-fifth day. In this example, which for convenience may be referred to as our Case viii, the condition was subacute as in our Case iv.

To the naked eye congestion and oedema are visible in most examples; haemorrhage into the leptomeninges and subdural space of the brain, one or two punctiform haemorrhages into the spinal cord, and blurring of the demarcation between the grey matter and white matter of the cord have been observed in some examples (Turnbull and McIntosh).

Microscopically focal histological changes extend from the cortex of the brain to the lumbo-sacral cord. The incidence was maximal in the lumbo-sacral cord and the pons, and was least in the upper cervical cord of our first seven cases. Case viii differs in that the affection of the spinal cord is greatest in thoracic segments; there it is of great severity. Perdrau found the most severe lesions in the pons and upper medulla, and the maximal lesions in the spinal cord in the lower thoracic segments and the lumbo-sacral enlargement. Schürmann found the maximum in the pons and medulla. Lucksch (brain and brain-stem) in the pons and substantia nigra; we found the inflammation in the mid-brain to be greatest in the substantia nigra. Schürmann found a fairly severe affection of the optic tract and nerves.

We found the white matter in the cerebrum to be more affected than the grey, but in the central nervous system, considered as a whole, we estimated that the grey matter was more affected than the white. Perdrau found the white to be most affected in the cerebrum and cerebellum, but the grey in the brain-stem and spinal cord. In the brain and brain-stem Bastiaanse considered the white matter to be most affected, Lucksch the grey and white to be about equally involved.

The histological changes can be divided into acute and subacute types. The acute type is usually found in patients who die from fourteen to seventeen days after vaccination, and the subacute in those who survive longer.

In the acute type there is a slight, intermittent infiltration of the leptomeninges, chiefly about veins, with small and large lymphocytes, plasmacytoid and true plasma cells, large mononuclear leucocytes, and endothelial cells. The

* Read in opening a discussion in the Section of Pathology and Bacteriology of the Annual Meeting of the British Medical Association, Cardiff, 1928.