

22 Davies: *Hydronephrosis*; Barrington: *Affections of Micturition*

The points of special interest are (1) that 20 years is an unusually early age at which to find closed renal tuberculosis with calcification; (2) that the case belongs to that group of closed renal tuberculous cases which proceed even to the stage of complete destruction of the parenchyma without giving rise to urinary symptoms of any kind; and (3) that although the organ showed an advanced stage of repair inasmuch as the whole kidney was replaced by calcifying caseous and fibrous tissue, yet it was still capable of disseminating tuberculous infection, as seen by the ulceration in the quadratus lumborum.

The ease with which an accurate diagnosis can be made in such a case, with the proper interpretation of the radiographic and cystoscopic findings, is a point of more practical interest.

Hydronephrosis of Left Kidney due to Stricture of Pelvi-Ureteral Junction.

By D. S. DAVIES, M.B.

The specimen is a left kidney removed by operation from a male patient, aged 46. The organ shows moderate enlargement and on section the pelvis is seen to be markedly dilated. This dilatation has extended so that the cortex is somewhat thinned and the calices enlarged. At operation two small stones were found occupying two of the lower calices. The pelvic mucosa is congested and thickened as a result of pyelitis. The most striking lesion, however, is the marked stenosis at the pelvi-ureteral junction. Here is a definite stricture, well seen, because the specimen shows the whole extent of the pelvic and ureteric walls in this region.

Clinical features.—A remarkable feature in the case was the shortness of the history. The patient noticed slight hæmaturia three weeks before admission, and after one week's freedom from trouble, he had dull aching pain in the left loin for fourteen days. There was no frequency of urine, dysuria or other symptom pointing to the urinary tract.

On examination the left kidney was found palpable but not tender. Cystoscopy revealed no anatomical lesion, but it took 8½ minutes for the indigo-carmin to be excreted from the left kidney while it appeared in 4½ minutes from the right side. A pyelogram of the left kidney showed a well marked hydronephrosis of the pelvic type with two small stones in the lower pole of the kidney. The capacity of the pelvis for the opaque fluid was 30 c.c. Patient made a good recovery after the nephrectomy.

The special point of interest in this case is the definite pyelitis associated with a moderate hydronephrosis secondary to a ureteral stricture of unknown ætiology. In view of the smallness of the stones it is probable that they are secondary to this hydronephrosis.

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Affections of Micturition Resulting from Lesions of the Nervous System.

By F. J. F. BARRINGTON, M.S.

Anatomy of the Nerves to the Bladder and Urethra.

THREE pairs of nerves are concerned with micturition, but none of them exclusively so. The bladder and unstriped muscle of the proximal part of the urethra receive fibres from the hypogastric plexus. The hypogastric plexus on either side is formed by the anastomosis of branches of two nerves, the hypogastric nerve and the

Section of Urology

23

pelvic nerve [5, 7, 11]. The pudic nerve is concerned with micturition in that it gives rise to a branch which supplies the compressor urethræ.

The hypogastric nerve is part of the sympathetic system. The white rami of the most caudal of the anterior—and therefore of the mid-lumbar—spinal roots from which the sympathetic system arises, give off branches which run through the sympathetic chain to the inferior mesenteric ganglia. These branches are called the lumbar splanchnic nerves and most of their fibres which go to the bladder terminate round cells in the inferior mesenteric ganglia. The inferior mesenteric ganglia are situated on the sides of the origin of the inferior mesenteric artery. The hypogastric nerves arise in them by the axons of the cells round which the lumbar splanchnic fibres have arborized.

The pelvic nerve arises from two of the more caudally situated sacral roots, and therefore roots intervene, which contain no bladder fibres, between its origin from the cord and that of the sympathetic. Each of its fibres breaks up round a cell before its distribution to the bladder, but this cell is on the bladder wall and therefore distal to where the nerve itself breaks up into the branches to the hypogastric plexus.

The pudic nerve arises from the sacral roots and, being a nerve supplying skeletal muscle, has no cells interposed in its course between its origin and termination.

All three pairs of nerves contain afferent as well as efferent fibres, but as none of them exclusively supply the bladder and urethra it does not follow, in any particular case, that these are concerned with micturition.

The contraction of the bladder resulting from stimulation of the spinal cord is abolished if both hypogastric and both pelvic nerves are divided, from which it follows that these are the only direct ways in which the central nervous system can influence the bladder.

(1) Lesions of Peripheral Nerves.

Micturition is performed normally in dogs [14] and in cats [1] after division of both hypogastric nerves. In cats a slight degree of frequency follows the operation [2].

Division of both pelvic nerves in dogs [12] and in cats [1] is followed by retention of urine with overflow. If unrelieved the over-distension leads to submucous hæmorrhages which subsequently may produce ulceration of the mucous membrane, often accompanied by considerable hæmaturia. The animals show no distress and do not resent having the bladder squeezed, from which it seems certain that the pelvic nerves carry all the impulses leading to the distress which accompanies acute retention. After a variable period of days overflow with incontinence disappears, the animal then remains dry and voluntarily passes small quantities of urine in the ordinary way, but always has a large volume of residual urine. This condition is permanent, and persists after subsequent division of the hypogastric nerves. Division of the pudic nerves at this stage leads to some diminution in the residual urine, abolition of the voluntary acts of passing urine and a more or less continual dripping of urine from the urethra, which leads to the perineal region again being soaked with urine. It follows, therefore, that the voluntary acts of passing urine after division of both pelvic nerves are due to relaxation of the compressor urethræ through the pudic nerves, and that these nerves must carry impulses to the central nervous system which produce part of the conscious desire to micturate, though, for reasons already given, this cannot be the distressing sensation of retention.

The syndrome described, arising from division of the pelvic nerves in dogs and cats, occurs clinically in three circumstances. It is not uncommon after labour, it is usual in incarceration of a retroverted gravid uterus, and occasionally it follows pelvic operations, particularly excision of the rectum. In all three cases an over-distended bladder is discovered either because the patient complains of incontinence or in the

course of a routine examination and not because the patient complains of inability to micturate.

In the cases which follow labour this is not necessarily instrumental. Such patients, after relief by catheterization, pass urine themselves in a few days, but have a very large residual. The residual urine gradually diminishes and recovery is complete in a few weeks.

The usual complaint in cases of incarceration of a retroverted gravid uterus is that of incontinence of urine; examination shows that the bladder is distended, and no distress from retention is present. Such cases recover when retention and retroversion are relieved. In both these cases the loss of function of the pelvic nerves must be due to mechanical stretching or pressure, and not to any solution of continuity of the nerves.

The branches of the two lower sacral nerves which go to form the pelvic nerve in man are relatively long, and the pelvic nerve formed by their union breaks up into its branches almost at once. It follows that, except at a single point, at least two nerves must be divided on either side to destroy completely the sacral nerve supply to the bladder, a fact which probably accounts for the relative rarity of the abolition of micturition resulting from pelvic operations. When the injury has been done, retention with overflow results, which commonly leads to death from pyelonephritis before the patient has recovered from the operation. Should he escape this, small quantities of urine are passed voluntarily, but a large volume of residual urine persists; this usually becomes diminished upon the supervention of severe cystitis, but not in consequence of any other process.

After division of both pudic nerves cats micturate as before. They do, however, show more or less evidence of incontinence. Sometimes this can only be shown by the escape of a few drops of urine if the bladder is gently squeezed, sometimes the cat spontaneously loses a few drops when it is making some strong straining movement, such as jumping, and occasionally the lesion is followed by the loss of urine in drops during quiet movements [1]. The urethra between the internal meatus and the compressor urethræ, both in the cat [9] and in man [17], is closed by muscular contraction, and does not constantly contain urine except during micturition. The closure of this part of the urethra is strongest at the compressor urethræ [6], which is supplied by the pudic nerves.

From these facts it follows that the compressor urethræ, or its nerve supply, can be damaged in surgical operations without producing any serious degree of incontinence, only as long as the urethra between it and the internal meatus is intact. This injury is probably quite frequent in the course of the performance of external urethrotomy and no harm results. The urethra between the internal meatus and compressor urethræ is destroyed by suprapubic prostatectomy [17] and occasionally by prostatic suppuration; a perineal operation which involves the compressor urethræ after either of these is very likely to be followed by permanent incontinence.

The action of the compressor urethræ probably partly determines the relative incidence of prostatic abscess arising spontaneously from a urinary infection in the various forms of lower urinary obstruction. It is known, clinically, that spontaneously occurring prostatic abscess is a fairly frequent complication of urethral stricture and of central nervous diseases producing residual urine, but is very rare in senile enlargement of the prostate. In the last case the openings of the prostatic ducts are distal to the obstruction and therefore are not exposed to any increased pressure from the urine during micturition. In all nervous lesions producing residual urine and not involving the pudic nerves or their origin, urine is held at the compressor urethræ and therefore the openings of the prostatic ducts are continually subjected to intravesical pressure. In urethral stricture during

Section of Urology

25

micturition the pressure on the duct openings must be very greatly increased and it seems probable that in advanced cases the prostatic urethra is dilated and permanently full of urine. Rabbits occasionally acquire paraplegia after injuries of the cord due to fracture of the spine from muscular action. In such cases when retention of urine and overflow has resulted, the vesicula seminalis can be seen to be tensely distended with urine.

(2) Lesions of the Sacral Dorsal Roots.

In dogs [13] and in cats [1] division of all the dorsal spinal roots in the sacral region is followed by retention of urine with overflow incontinence, and hæmaturia may result. The urethra remains constantly firmly contracted. The urine drips away, is not passed in jets and is not passed voluntarily. The condition is permanent and it is not modified by subsequent division of the hypogastric nerves. As after division of both pelvic nerves, the urethra from the internal meatus to the compressor urethræ is full of urine. The bladder condition after this lesion is associated with dilatation of the rectum, but not with impotence.

Micturition is commonly affected in tabes, and where an affection is present it resembles that produced experimentally by division of the dorsal spinal roots in the sacral region. Impotence is also common in tabes, but is not necessarily associated with an affection of micturition. When micturition has become markedly deranged the patient complains of incontinence which is worse at nights. Difficulty in micturition is not as a rule complained of, though the patient generally admits he has to strain to get the urine away. Frequency is present, but is entirely voluntary; either no desire to pass urine is ever experienced, or the desire and the passage of urine occur nearly simultaneously. In both cases the patient has learnt by experience that he keeps drier if he makes repeated efforts to pass urine at times when he has no desire to do so. The symptoms are associated with a large volume of residual urine and a greatly increased tolerance to artificial distension of the bladder, except when the walls of the latter have been markedly altered by inflammation.

The constant presence of residual urine, and of urine in the prostatic urethra in cases of tabes with an affection of micturition, is of significance if a prostatic abscess develops and is opened in the ordinary way through a perineal incision. As in other cases of prostatic abscess the abscess has generally made a communication with the prostatic urethra or bladder, or both, by the time it is opened. The effect of opening it is therefore to make an external fistula. This is of no significance in prostatic abscesses in other conditions, but in tabes the internal opening will be constantly exposed to urine under a positive pressure. This will always lead to delay in healing and may make the fistula permanent, a condition which can only be dealt with by a permanent suprapubic cystotomy.

(3) Lesions of the Central Nervous Axis.

Many experimental observations on micturition have been made by passing a catheter in female animals under an anæsthetic and gradually distending the bladder with warm water; with a certain distension a reflex contraction of the bladder results, leading to the expulsion of a greater or less part of the water at the side of the catheter; this has been called reflex micturition. The method, at least in cats, is not of much use, as the anæsthetic greatly interferes with the reaction and a considerable volume of residual is usual. If, however, the same thing is done on a decerebrate cat which has been allowed to come round from the anæsthetic, the residual is insignificant and not more than the interference of the catheter might easily account for. Further, if a decerebrate cat is kept alive by careful regulation

of its surrounding temperature for a sufficient time, micturition can occur spontaneously without any appreciable residual urine. Owing to ossification of the tentorium the plane of decerebration is fairly constant and goes through the superior colliculi on the dorsal side and through the crura at the superficial origin of the third nerves ventrally. Micturition can therefore take place in the absence of the parts of the brain in front of this plane and animals on which the operation has been performed can be used for its further investigation.

In the cat there are about 3 cm. of urethra between the internal meatus and the prostate. If this is divided proximally and a cannula tied into each cut end, the bladder contraction and urethra relaxation can be observed under varying conditions by means of a water manometer connected with each cannula. The paths of the reflexes so observed, and their level in the central nervous system, can be determined by section of various pairs of nerves and by transecting the cord or brain stem at various levels respectively. In this way micturition can be found to be composed of five reflexes [3] as follows:—

(1) Distension of the bladder gives rise to strong contraction of the bladder. Both efferent and afferent paths are in the pelvic nerves and the reflex is situated in the hind brain.

(2) Running water through the urethra gives rise to strong contraction of the bladder. The efferent path is in the pelvic nerve, the afferent in the pudic, and the reflex is situated in the hind brain.

(3) Distension of the urethra between the internal meatus and compressor urethræ gives rise to weak contraction of the bladder. Both efferent and afferent paths are in the hypogastric nerves and the reflex is situated in the cord.

(4) Running water through the urethra gives rise to relaxation of the urethra. Both paths are in the pudic nerves and the reflex is situated in the cord.

(5) Distension of the bladder gives rise to relaxation of the urethra. The efferent path is in the pudic nerve, the afferent in the pelvic and the reflex is situated in the cord.

It is evident that these reflexes are such that when one arises the others are brought into action by it. From this it follows that the undoubted existence of a direct voluntary control over micturition does not necessarily imply a direct voluntary control over the smooth muscle of the bladder. For instance, if the stimulus to the bladder contraction in the second reflex is not the actual running of water through the urethra, but the relaxation of the compressor urethræ produced by this through the fourth reflex, voluntary micturition could be produced by voluntary relaxation of the compressor urethræ, which is a striped muscle.

These reflexes make it plain why urine is normally held at the internal meatus. After paralysis of the compressor by division of both pudic nerves, the urethra between the compressor and the bladder still remains closed and a certain, though much smaller, pressure is required to force it open. This pressure is greater than that necessary to evoke the first reflex and therefore micturition occurs before the posterior urethra can become chronically distended. If, however, the pelvic nerves, dorsal sacral roots or spinal cord are divided the first reflex is destroyed, and then the urethra between the bladder and compressor becomes chronically distended.

The second reflex can easily be produced experimentally, when a catheter has been passed, by slightly withdrawing and then pushing back the catheter; it therefore explains the importance of holding a cystoscope still when an irritable bladder is being washed out.

In cats and dogs transection of the spinal cord in front of the sacral region at any level compatible with life is followed by retention of urine and overflow. After some days a condition known as spontaneous (or automatic) micturition appears [8]

Section of Urology

27

together with a considerable diminution in the volume of residual urine. When spontaneous micturition has appeared the animal passes urine periodically in series of rhythmic jets, the first jet of each series generally being the largest. The jets often seem to occur spontaneously and are then probably provoked by distension of the bladder or proximal urethra. They may easily be elicited by touching the perineal region or by anything calculated to increase the pressure in the bladder or proximal urethra, such as any strong movement, holding the animal vertically, or slight pressure on the abdomen. There is always an appreciable and generally a large residual urine. The rhythmic jets of urine can be seen to occur at the same intervals as rhythmic contraction of the perineal muscles. The development of spontaneous micturition appears to depend entirely on the lowering of the urethral resistance which gradually follows after a spinal transection and which is possibly higher than normal immediately after the lesion. This decrease in the resistance to the escape of urine can be felt to occur if the bladder is partially emptied by compression through the abdominal wall. Rhythmic relaxations in the resistance of the urethra can be felt to occur from the first, before the establishment of spontaneous micturition, but it seems that when the resistance is high its difference in these rhythmic relaxations is insignificant for the intravesical pressure, and therefore no jets of urine result. Spontaneous micturition does not appear to arise from a re-establishment of reflex contraction of the bladder, since, if a cat with a spinal transection, in which it has become established, is decerebrated and the reflexes of the bladder and urethra already described are examined, the first and second reflexes cannot be elicited.

Transverse lesions of the cord in man give rise to the same effects on micturition as in dogs and cats, but in the latter stages these are always modified by a greater or less alteration in the bladder from infection.

The efferent paths of micturition in the spinal cord in dogs [14] and cats [15, 16] are in the dorsal parts of the lateral columns. These are affected in man in Erb's paraplegia, typically an extensor plantar response is also present, but it seems probable that micturition is not infrequently affected alone. In this case diagnostic errors are likely to occur, particularly if the patient happens also to have an enlarged prostate.

The position of the micturition reflexes in the hind brain of the cat was found by means of the stereotaxic instrument of Clarke [10]. Bilateral lesions at the anterior end of the hind brain just ventral to the internal edges of the superior cerebellar peduncles resulted in a large volume of residual urine, whereas similar lesions near but not exactly in this position did not affect micturition [4]. This is not a part of the brain where chronic disease is frequent in man; retention of urine, however, does occur in pontine gliomas.

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