MANAGEMENT OF THE BLADDER IN SPINAL INJURIES*

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The management of the bladder in spinal injuries is only too often a prolonged and arduous task. At the same time it is frequently possible to assist and make more comfortable patients whose troubles appear at first sight to be hopeless. Occasionally a real success brings lasting satisfaction to the patient and encouragement to the urologist.

The Act of Micturition

Although in normal circumstances micturition is under voluntary control, it is essentially a reflex act. The gradually increasing intravesical pressure causes the "stretch reflex," which in turn initiates contraction of the detrusor muscle, thus emptying the bladder.

It has been estimated that an intravesical pressure of between 18 and 43 cm. of water induces a desire to micturate. The wish to evacuate the bladder is dependent on the intravesical pressure, but is not always directly related to the amount of urine present. The bladder can find room for an increasing quantity of urine (within certain limits) by relaxation of muscle, but at a constant intravesical pressure.

It is interesting and perhaps important that the pressure caused by reflex contraction is not as great as the pressure in the bladder induced by voluntary contraction of the abdominal wall. This might well solve the main problem but for the fact that unless the detrusor muscle goes into action the bladder neck does not relax (Denny-Brown and Robertson, 1933). These writers believe that the internal sphincter contracts and relaxes in reciprocity with the detrusor. The interaction of the detrusor and internal sphincter probably initiates a further reflex resulting in relaxation of the external sphincter. The final outcome of these still somewhat obscure nervous mechanisms is the act of micturition.

Voluntary Control of Micturition.—Micturition is primarily a reflex act, but can be controlled by the cerebrum. Langworthy *et al.* (1940) state that "there is evidence of cortical representation over the function of micturition" and that "the co-ordination of vesical function is dependent on reflex arcs through the mid-brain." It is probable that between the acts of micturition inhibitory impulses from the cerebral cortex are in control, and that it is the voluntary cessation of such inhibitory impulses which permits the reflex act to take place. The external sphincter can be voluntarily contracted but not voluntarily relaxed.

Nerve Supply of the Bladder.—The centre of micturition is situated in the sacral cord opposite the twelfth thoracic and first lumbar vertebral bodies. Both motor and sensory nerves reach the bladder from the second, third, and fourth sacral segments by the nervi erigentes or pelvic nerves. The sympathetic nerves are vaguely concerned with sensory aspects and play little or no part in the reflex act of micturition. It is suggested that

any effect the hypogastric nerves exercise on the internal sphincter is concerned with ejaculation and not with micturition. The external sphincter muscle is supplied by the perineal or pudendal nerve arising from the pudic (second, third, and fourth sacral).

Various Results of Spinal Injury

The well-known term "spinal shock" has been in use for well over a century, being first used by Marshall Hall in 1843. Munro (1937) has defined it as "that condition which, when caused by spinal injury of any type, produces suppression or alteration of segmental reflex activity below the level of the cord injury."

Immediately after the injury the condition is known as:

Atonic Neurogenic Bladder.—The bladder becomes greatly distended and a paralytic overflow incontinence ensues. The only factor ensuring any evacuation of the bladder is the elasticity of its wall. This phase occurs in almost all cases, and lasts from days to weeks, or even months. As the patient gradually recovers from his spinal shock he passes into one of two further categories, depending on the level of the injury (Donovan, 1949).

The Automatic Bladder.—This condition, sometimes known as the reflex bladder, occurs when the injury has occurred above the centre for micturition, which has remained unscathed. The patient has no control over micturition, which occurs at intervals of up to three or four hours, but usually hourly. Several ounces of urine are forcibly evacuated, the amount of residual urine varying from case to case.

The Autonomous Bladder.—When the spinal injury has involved the centre for micturition, this type of bladder is to be expected. There is a continual dribbling from the bladder, which may be partly emptied by manual compression of the abdomen. Residual urine and secondary dilatation of the ureters due to back pressure are common.

Voluntary Neurogenic Bladder (Prather, 1949).—Prather points out that after partial transection of the spinal cord there will probably be some degree of sensation and some degree of voluntary motor power, though neither may be apparent for a lapse of time after the injury. There is considerable hope that in such patients voluntary micturition, though imperfect, may ultimately be achieved. This type of bladder has been compared to the uninhibited bladder of enuresis.

Investigation

The above are long-stay cases, and an initial investigation is valueless unless repeated every three months. Urinary infections wax and wane, stones may develop, and perhaps a hydro-ureter makes its appearance over a period of time.

Investigation includes the following:

Examination of Urine.—These cases of spinal injury provide a war of attrition with chronic urinary infection subject to acute exacerbations. The work of David (1921) is interesting in this respect. He found that the injection of *Bact. coli* into the bladders of normal dogs produced no harmful effect, the organisms gradually disappearing without causing any cystitis. If the dog had, however, any residual urine, the injection of *Bact. coli* into the bladder produced severe cystitis and renal infection. It is interesting to compare cases of Pott's disease of the spine with spinal injuries. At Wrightington Sanatorium, where I see many cases of Pott's disease suspected of possible genito-urinary tuberculosis, infection with ordinary pyogenic organisms is the exception, whereas at the Spinal Centre at Southport urinary infection is almost the rule.

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Radiograph of the Urinary Tract.—A straight radiograph of the urinary tract and an intravenous pyelogram is not only necessary in the initial stages of the investigation but must be repeated at three-monthly periods at least. A renal calculus may develop while the patient is under treatment or a hydro-ureter or hydronephrosis may appear insidiously. In certain intractable cases it is possible to demonstrate progressive deterioration of renal function over a period of years.

Cysto-urethroscopy.—In the earlier stages the bladder mucosa tends to be somewhat atrophic and to exhibit a fine trabeculation. As time goes on the trabeculation becomes more pronounced. The degree of trabeculation must not, however, be regarded as always indicating a bladder-neck obstruction, as it is sometimes seen in cases of catheter drainage. With regard to the bladder neck, probably other methods of investigation are more definite and helpful, but it is often possible to demonstrate a constriction or an indurative lesion, similar to a median bar, and forming a cuff of fibrous tissue and hypertrophied muscle. There frequently seems to be a chronic inflammatory change present at the bladder neck, suggested both by a bullous oedema of the trigone and by a lack of elasticity or fixity of the tissues in the immediate neighbourhood. I have no personal experience of Simons's (1936) method of sphincterometry, but I hope to introduce this additional method of investigation, as it seems likely that one of the bladder-neck resection failures was due to spasm of the external sphincter, which might have been identified before operation, and possibly treated by pudendal nerve block with better results.

Cystometric Studies.—Cystometry, or the relation of the volume of fluid in the bladder to the intravesical pressure, is of value in indicating detrusor contractions, bladder

capacity, bladder sensation, especially the pain on distension, and maximum voluntary pressure. As long ago as 1934 Watkins, of Manchester, demonstrated the cystometric curves found in normal individuals, and indicated the upper and lower limits of normality. Fig. 1 shows the cystometrogram seen in atonic neurogenic bladder, the first phase after injury; there are no reflex detrusor waves. The maximum voluntary pressure (M.V.P.) is dependent on the level of the lesion, as it requires full activity of the abdominal muscles to be effective. Where there is no paralysis of the abdominal musculature a muscular effort ably assists the reflex detrusor effort. The cystometrogram usually found in the automatic or reflex bladder is shown in Fig. 2. Reflex contractions occur during the gradual filling of the bladder, but micturition (as shown by leakage around the catheter) does not occur until a moderate volume of fluid has been run in. Fig. 3 shows the position in the autonomous bladder.

FIG. 1.—Cystometrogram in a case of atonic neurogenic bladder.

FIG. 2.—Cystometrogram in a case of automatic bladder (injury at T3). X = Leakage around catheter.

FIG. 3.—Cystometrogram in a case of autonomous bladder (injury at L1). Residual urine = 14 oz. (400 ml.).

It has been suggested that the cystometrogram is of no value, but one simple illustration of its use will suffice: in the absence of reflex detrusor contractions it is obvious that caution must be exercised in closing a suprapubic fistula.

Cystography.—Cystography, or more strictly cysto-urethrography, has been employed more and more

FIG. 4.—Cysto-urethrogram indicating a shelf-like obstruction at the bladder neck.

at the Southport Spinal Centre, as it has been found to be an invaluable method of investigation. The consensus of opinion appears to be that the bladder neck is dilated in many cases of spinal injuries, but this is not true in all cases. Cysto-urethrography has been used to demonstrate a shelf-like obstruction at the bladder neck, and has been repeated after resection of the bladder neck to indicate whether enough tissue has been removed (Fig. 4).

Residual Urine.—A consistently high residual urine—say 10 oz. (284 ml.)—may be regarded as an indication for resection of the bladder neck. No case of spinal injury can hope to escape recurrent bouts of acute urinary infection if there is a high residual urine.

Complications of Spinal Injuries

The three menacing complications are infection, stone formation, and hydronephrosis with hydro-ureter.

Infection

Of these three the most dangerous, intractable, and persistent is infection. The route of infection is interesting, as in many cases reflux cannot be demonstrated and the infection must pass to the kidney either by the blood stream or by the lymphatics.

It seems almost impossible to keep the urine of these cases permanently sterile, and there always appear to be a few pus cells and stray bacteria in the urine. One causative factor is undoubtedly the presence of residual urine. Possibly, also, there is damage to the bladder wall due to prolonged overstretching during the initial stage. In the later phases it is found that overdistension, even for a few hours, may cause the temporary disappearance of reflex contractions.

Treatment consists in dealing with the acute attack of urinary infection with the sulphonamides, penicillin, or streptomycin, according to the sensitivity of the organisms concerned; it may be necessary to continue the course of treatment for a week. During the quiescent periods between the acute attacks prophylactic measures include forced diuresis—as much as six pints (3.4 litres) of fluid in 24 hours—and the elimination of urinary stagnation and of all obstructive factors. Finally, all authorities agree that the general condition of the patient is of great importance, especially regarding the elimination of toxæmia due to bed-sores. In experimental animals with transection of the cord, similar organisms have been found in the urine and in the bed-sores.

Urinary Calculus Formation

Unfortunately, stone formation is a common complication, approximately 9% to 31% of cases of spinal injury being thus involved. Flocks (1946) considers that there are three aetiological factors—infection, stasis (due to recumbency), and hypercalciuria. Stones can develop rapidly, hence routine x-ray examination is necessary at three-monthly intervals. I have often noticed that the stone is almost pultaceous in consistency and does not show very clearly in the radiograph. As might be expected, symptoms are trivial, and pain, especially renal colic, is generally absent. Recurrent bouts of pyrexia strongly suggest a calculus. Once the patient becomes ambulatory the tendency to stone formation diminishes. In the presence of postural stones it is advisable to maintain the urine acid (about pH 5) by the administration of ammonium chloride, which may be given in the form of cachets.

It may be necessary to remove the stone under certain circumstances, such as: (1) a stone obstructing the pelvis

and causing hydronephrosis (it is not always necessary to remove a calyceal stone); (2) ureteric calculi which are impacted and causing obstruction; and (3) all stones in the bladder (usually by lithotripsy).

In all surgical measures conservatism is the vital principle, and the kidney is removed only when disease has deprived it of all secretory tissue. The use of solution G either by means of a nephrostomy or by an irrigating ureteric catheter has, on the whole, proved disappointing, though one or two successes have followed its use.

Prognosis

As might be expected, in incomplete lesions of the spinal cord bladder recovery is earlier and more complete. In incomplete lesions between T11 and L5 the results are especially satisfactory because the distended overflowing bladder somewhat resembles the condition seen in prostatic obstruction and similarly responds to resection.

In complete transections a relatively satisfactory result may be achieved in lesions situated above the centre for micturition. In complete injuries below L5 the outlook is extremely grave, the only hope being the integrity of the abdominal muscles.

Practical Management

Prather (1949) states the aims of treatment simply and concisely. He says: "The patient should become ambulatory and free of urinary infection. A patient who has sustained a *partial* transection of the spinal cord should attain voluntary control of urination and be capable of emptying his bladder. A patient who has a *complete* transection of the spinal cord should attain involuntary, periodic reflex voiding at satisfactory intervals and be capable of emptying the bladder."

Cases of spinal injury are scarcely ever admitted direct to the spinal centre, but are usually transferred from some other hospital. This is unfortunate, but it remains a hard fact. In view of the observations, mentioned above, regarding the damage to the bladder wall by overdistension, it would seem that the "non-interference" method is undesirable. Moreover, the particular difficulties in attempting this method in female patients have been emphasized by Riches (1943).

While disliking catheterization, I admit that there may be cases in which its use is indicated in spite of the great danger of encouraging a urinary infection, especially as the antibiotics have rendered this complication less formidable. Needless to say, if the urethral catheter is to be used at all, its use is permissible only with the greatest precautions and only in hospital.

If a neurological investigation makes it clear that the lesion is a partial transection of the cord (should this be possible at an early stage) it may be justifiable to drain the bladder by an indwelling catheter, provided the catheter is connected with a closed sterile drainage system. I am rather opposed to tidal drainage, as, in spite of the greatest care and trouble, it is not always possible to ensure complete emptying of the bladder, and there is thus a danger of leaving a puddle of pus and calcareous debris after siphoning off the supernatant fluid. A serious objection to the indwelling catheter is that possibly the urethral mucosa responds to the pressure of the catheter in a similar manner to the reaction of the skin over the buttocks to pressure. A catheter-sore may be produced in the urethra similar to a bed-sore over the sacrum.

In all cases of complete transection of the cord, and in all cases of doubt, the right course initially is to carry out suprapubic drainage, preferably using a small Riches (1943) catheter, placed well above the pubis. It may be many weeks or months before reflex micturition is established, and the management of such a case with a suprapubic catheter is infinitely easier and more efficient than with urethral drainage. The fact that a suprapubic opening has been made does not prejudice the subsequent development of automatic or normal micturition. The small opening left by a Riches catheter closes very readily, or it is an easy task to close the suprapubic fistula surgically; that is, provided there is evidence of reflex detrusor contractions in the cystometrogram and provided there is no obstruction at the bladder neck. Needless to say, the catheter must be changed every five or six days to prevent encrustation.

Bladder training should begin when the reflex or automatic stage has been reached. The catheter should be released at regular intervals by the clock. After removal of the catheter, attention should be directed to regular evacuation of the bladder (again by the clock) by control of the intake of fluid.

The light penile clamp may be useful in the case of the bladder which is constantly dribbling, though some American authorities condemn it. Its use depends on the intelligent co-operation of the patient.

Resection of the Bladder Neck

Resection of the bladder neck is the most interesting and certainly the most promising advance in the treatment of this condition. Emmett (1945) believes that in spinal injuries the internal sphincter acts in close conjunction with the detrusor and, contracting with it, constitutes an obstruction at the bladder neck. Although in many cases of spinal injury there is dilatation of the bladder neck, in some there seems to be an indurative condition, similar to a median bar, at the internal urinary meatus. In my opinion the patient should satisfy certain strict criteria before being considered suitable for resection. These include: (1) a persistent and large residual urine; (2) satisfactory reflex detrusor contractions in the cystometrogram; and (3) a demonstrable obstruction by cysto-urethroscopy or by cysto-urethrogram.

Resection is probably most often indicated in the autonomous bladder. For the actual resection I use a Gershom-Thomson cold punch, removing eight to ten strips from 5 to 8 o'clock from the bladder neck, the strips extending from the highest point of the verumontanum upwards to the internal urinary meatus. The greatest care must be exercised, as there is little thickness of tissue between the prostatic urethra and the prostatic capsule. It is better to remove too little and be prepared to repeat the operation if necessary (Lane, 1950, personal communication).

In carefully selected cases it is possible to achieve most satisfactory results with this method. The residual urine falls sharply, the tendency to infection diminishes, and it is possible to allow the suprapubic opening to close. In some cases it is also possible to demonstrate the disappearance of hydronephrosis and hydro-ureter.

I have carried out this operation in 16 cases, but further experience is necessary before a full evaluation of the method is available. A careful analysis of the last seven cases revealed two successes, improvement in two, and three failures.

Other Methods

Other possible methods of treatment include the use of a fascial sling (by Millin's method) formed from the rectus sheath in cases in which the abdominal muscles are under voluntary control and the external sphincter is paralysed. Recently, Bors, Comarr, and Moulton (1950), working in the Veterans' Hospital, California, have suggested four additional methods of treatment: (1) spinal anaesthesia, (2) subarachnoid alcohol block, (3) pudendal nerve block, and (4) vesical neck anaesthesia.

A pudendal nerve block to induce a paralysis of the external sphincter muscle has been carried out on two of my cases with apparent benefit, but this work is still at an early stage of development. It is in this type that cysto-urethrography should prove so useful, indicating the exact site of the obstruction, whether at the bladder neck, at the external sphincter, or in the prostatic urethra, the so-called pseudo-sphincter level.

Conclusion

It is necessary to emphasize that it is possible to deal with these cases only at a special centre. Collaboration between neurologist, neurosurgeon, plastic surgeon, orthopaedic surgeon, and urologist is effective only if they are all interested in and accustomed to dealing with the particular problem. It is also necessary to mention that the nursing of these patients requires the most specialized knowledge and care.

Finally, although the management of these cases is troublesome and tedious in the extreme, the figures are encouraging. After the 1914-18 war only 10% were alive a year after injury, whereas now 85% are alive at the end of a similar period.

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REFERENCES

- Bors, E., Comarr, A. E., and Moulton, Stanley H. (1950). *J. Urol.*, **63**, 653.
 David, V. C. (1921). *J. Amer. med. Ass.*, **76**, 494.
 Denny-Brown, D., and Robertson, E. G. (1933). *Brain*, **56**, 397.
 Donovan, H. (1949). *Postgrad. med. J.*, **25**, 383.
 Emmett, J. L. (1945). *J. Urol.*, **53**, 545.
 Flocks, R. H. (1946). *J. Amer. med. Ass.*, **130**, 913.
 Langworthy, O. R., Kolb, L. C., and Lewis, L. G. (1940). *Physiology of Micturition*. Williams and Wilkins Co., Baltimore.
 Munro, D. (1937). *Amer. J. Surg.*, **39**, 120.
 Prather, G. C. (1949). *Urological Aspects of Spinal Cord Injuries*. Blackwell Scientific Pub., Oxford.
 Riches, E. W. (1943). *Brit. J. Surg.*, **31**, 135.
 Simons, I. (1936). *J. Urol.*, **36**, 88.
 Watkins, K. H. (1934). *Brit. J. Urol.*, **6**, 104.

Speaking at Cardiff recently, the Minister of Health said that the incidence of infant mortality and maternal mortality was heavier in Wales than in England, but there had been a striking improvement recently. Between 1938 and 1945 the figure of infant mortality for England and Wales had fallen from 53 to 46 per 1,000 and in Wales from 57 to 55. In the years of peace and full employment from 1945 to 1949, while the England and Wales figure had fallen from 46 to 32, the Welsh figure had fallen equally fast—from 55 to 40. Though the difference between the countries left no room for complacency, the rapid improvement was a cause for national satisfaction. In one matter Wales had taken the lead. Up to January 31 of this year 325 trained nurses and 2,169 auxiliaries had been enrolled in Wales for the National Hospital Service Reserve—a total of 2,494. He praised the work on pneumoconiosis done by many research workers, especially at the research unit at Llandough Hospital.