SACRAL NERVE INNERVATION OF THE HUMAN BLADDER*

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(Received for publication October 8, 1947)

The large number of patients with paraplegia resulting from World War II has created new interest in the neurogenic bladder, and consequently in bladder innervation. Advances in the control of urinary tract infections and in rehabilitative procedures have been extensive, giving patients with spinal cord injuries life expectancies of many years, instead of the average of 18 months after World War I. It has been possible for many patients with a paraplegia to return to useful community life. Many have not been able to attain this goal because of their inability to exercise control over urination. The problem of adequate control of urination becomes more difficult in neurogenic bladders treated for months or years with indwelling catheters. A thickened and chronically infected bladder wall with marked hypertonicity and very limited capacity is the almost inevitable result of such treatment. The bladder becomes useless as a reservoir for urine. A large number of patients with bladders in this condition were available for study, and the present investigation of the nerve supply to the bladder was carried out in an effort to throw some light on possible therapy.

The investigation was limited to the sacral nerves for the following reasons: (1) There is little evidence that the hypogastric nerves, the other source of bladder innervation, have any great effect on bladder function.2-5,7,12,14,15,16,17 (2) The lumbar sympathetic nerves have been removed in many patients without apparent deleterious effects on bladder function. (3) Bladder automaticity usually appears after spinal cord injury before any evidence of reflex sympathetic activity is seen. (4) The sacral nerves are readily accessible as they emerge from their corresponding sacral foramina. (5) During the operation of anterior rhizotomy for disabling spasticity,8 the question arose as to which sacral nerves must be spared to maintain automatic bladder function.

Knowledge of human bladder innervation has been taken largely from comparison with experimental animals20,21 and from anatomical dissections. Latarjet and Bonnet13 found from their dissections that the 3rd sacral nerve (S3) and the 4th sacral nerve (S4) contribute fibers to the bladder. Cordier6

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* Presented at the 31st Annual Meeting of the American Physiological Society on May 22, 1947. Aided in part by a grant from the Veterans Administration and published with the permission of the Chief Medical Director of the Department of Medicine and Surgery of the Veterans Administration, who assumes no responsibility for the opinions expressed or conclusions drawn by the authors.

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found that the 2nd sacral nerve (S2), the 3rd sacral nerve, the 4th sacral nerve, and in one specimen, the 1st sacral nerve (S1) were involved in bladder innervation. Harman⁹ concluded from nerve fiber counts in human fetuses that S3 carries the largest number of fibers to the bladder, with S2 and S4 supplying fewer fibers. He also found that S4 supplied more fibers than did S2. Hovelacque¹¹ came to the same conclusions from his dissections. In more recent studies, Coates⁶ found that S2 and S3 supply the bladder, and Trumble²⁰ states that the pelvic nerves always rise from S3, with S2 and S4 giving some fibers to them. Thus, it would appear that S3 is constant in supplying nerve fibers to the bladder, while there is some variation in the contributions of S2 and S4.

METHOD

A group of 12 male paraplegias, unsuccessfully treated for 6 months or more with tidal drainage¹⁸ after varying types of initial treatment, was chosen for study. Bladder tone was measured cystometrically, using the following standard technique: The regular irrigating fluid, Suby's solution,¹⁹ was introduced through an indwelling catheter at the rate of 10 cc. per minute from a height of 1 m. above the bladder. Intravesical pressure was measured with a water manometer and was recorded graphically after the addition of each 50 cc. of fluid. The cystometric study was terminated if the intravesical pressure rose to 70 cm. of fluid and the detrusor would not relax until the bladder was emptied. It was stopped if leakage occurred around the catheter, or when 400 cc. of solution had been introduced into the bladder. Several control cystometric studies were performed with the patient supine and at complete rest at the start of each study. The cystometric curves obtained on each individual were almost identical with the ones that had been obtained over a period of months. The patient was then placed in the prone position, and bilateral blocks of the desired nerve roots were performed, using 0.5 or 1 per cent novocaine solution. The injections were made through the sacral foramina, which were identified either by roentgenographic study or by palpation through the atrophic musculature. Only 3 to 5 cc. of the anesthetic solution were injected into each foramen to minimize spread to adjacent roots. At the completion of the injections, the patient was returned to the supine position. Cystometric studies then were repeated immediately and at intervals of ½ hour, 1 hour, and 2 hours. The curve shown in Figs. 1–9 are those obtained immediately after the blocks. They show the greatest variation from control curves. In each of these curves, the ordinate is in cm. of fluid pressure and the abscissa is in cc. of fluid added. At least 24 hours was allowed to elapse between injection of different nerves to assure complete recovery of the nerves. A rough estimate of sphincter tone was considered to be had in the presence or absence of leakage of fluid from the urethra when the intravesical pressure reached 70 cm. or above. After some nerve blocks, leakage occurred at intravesical pressures lower than during control observations. In these cases it was considered that relaxation of the sphincter had occurred (Fig. 1).