Pelvic Autonomic Nerve Mapping Around the Prostate by Intraoperative Electrical Stimulation With Simultaneous Measurement of Intracavernous and Intraurethral Pressure

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Purpose: In previous studies we noted that the neurovascular bundle was not identical to the bundle of the cavernous nerve fibers. In this study we sought to prove these anatomical findings electrophysiologically and map the autonomic nerve fibers by intraoperative simultaneous measurement of intracavernous pressure and intraurethral pressure.

Materials and Methods: Between January 2004 and May 2005 electrical stimulation was performed in 27 open pelvic surgeries, including 26 radical retropubic prostatectomies and 1 radical cystectomy, using an original bipolar electrode before prostate removal. Nerve stimulation was performed at the base of the so-called neurovascular bundle (point A) and the rectal wall about 1 cm posterolateral, apart from the neurovascular bundle (point B). Intracavernous pressure and intraurethral pressure were measured simultaneously.

Results: The mean ± SD increase in intracavernous pressure was 9.8 ± 6.3 cm H_2O at point A and 13.5 ± 7.3 cm H_2O at point B. Intracavernous pressure at point B was significantly higher than at point A ($p = 0.0240$). The mean increase in intraurethral pressure was 17.0 ± 9.4 cm H_2O at point A and 11.2 ± 8.1 cm H_2O at point B. Intraurethral pressure at point A was significantly higher than at point B ($p = 0.0353$).

Conclusions: The course of the cavernous nerves did not always agree with the surgically identified neurovascular bundle. The distribution of cavernous nerves was wider than our image of the neurovascular bundle and it existed on the rectal wall posterolateral, apart from the neurovascular bundle rather than the neurovascular bundle itself. The surgically identified neurovascular bundle contained the nerve fibers contributing to urinary continence.

Key Words: prostate, prostatectomy, urinary continence, electric stimulation, neuroanatomy

Sexual potency and stress incontinence are common comorbidities associated with radical prostatectomy. To improve postoperative quality of life we have studied the pelvic neuroanatomy, especially the NVB, using adult fresh and fixed cadavers.[1,2] We noted that the NVB is likely to differ from the actual course of the cavernous nerve fibers. The macroscopically identified NVB contains many nerve fibers to the cavernous tissue, urethral sphincter and bottom of the levator ani muscle (fig. 1, *A*). Microscopically we can detect the nerve fibers to the cavernous tissues and urethral sphincter between the membranous urethra and levator ani muscle fascia (fig. 1, *B*).

The most popular device for intraoperative NVB electrical stimulation is the CaverMap Surgical Aid (Uromed Corp., Boston, Massachusetts). Some groups reported that the potency rate in CaverMap positive cases after prostatectomy was significantly higher than in conventional nerve sparing cases.[3,4] However, others noted that the result of CaverMap did not correlate with the potency rate.[5,6] We also invented a simple and reliable monitoring system to confirm the cavernous nerves.[7] There is only 1 study describing IUP after stimulation.[8] We sought to prove these anatomical findings electrophysiologically and map the autonomic nerve fibers by intraoperative simultaneous measurement of ICP and IUP.

MATERIALS AND METHODS

Between January 2004 and May 2005, 26 patients who underwent open radical prostatectomy and 1 who underwent open radical cystectomy were approached to participate in this institutional review board approved study of male neuroanatomy. In these 27 patients age was 57 to 79 years (mean ± SD 70.0 ± 5.2). No patient had a history of pelvic surgery, pelvic irradiation, transurethral surgery or neurological disease. Only 1 patient with prostate cancer had received neoadjuvant androgen deprivation therapy for 6 months. Surgery was performed using general anesthesia with propofol for induction, N_2O plus sevoflurane for maintenance, vecuronium bromide as the muscle relaxant and

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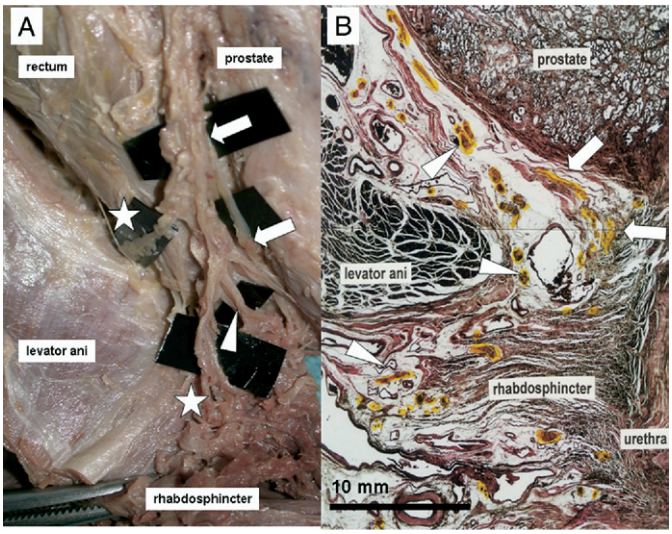

FIG. 1. *A*, macroscopic dissection of so-called right NVB in fixed cadaver. NVB contains many nerve fibers to cavernous tissue (arrowhead), urethral sphincter (arrow) and bottom of levator ani muscle (star). *B*, frontal histological section around so-called right NVB stained with hematoxylin and eosin. Some nerve fibers go to cavernous tissues and urethral sphincter between membranous urethra and levator ani muscle fascia. H & E stain.

epidural anesthesia with fentanyl citrate plus ropivacaine hydrochloride hydrate.

After we incised the endopelvic fascia the posterolateral aspect of the prostate and lateral rectal wall were exposed, where the cavernous nerves and autonomic continence nerves should run toward the membranous urethra.[1,2] Electrical stimulation was performed using a Neuropack nerve stimulator device (Nippon Kohden, Tokyo, Japan) and a bipolar electrode before prostate removal (fig. 2). The interval between the 2 electrodes was 7 mm long. As described previously,[7] stimulation was administered for 30 seconds using certain conditions, including a monophasic rectangular pulse, 50 mA, 10Hz and 0.2-millisecond duration.

We measured ICP with a 23 gauge needle inserted into the corpus cavernosum of the penis at the penile root, connected to a Menuet compact urodynamic device (Dantec Medical, Skovlunde, Denmark) through an SCKD-5006 disposable pressure transducer set (Nippon Kohden). IUP was measured with an intraurethral balloon catheter, which was especially ordered, and a 7.5Fr catheter with a 5 cm A4219 balloon (Fuji System, Tokyo, Japan) (outer diameter 2.5 mm). After we examined catheter insertion by transrectal ultrasound we positioned the balloon filled with sterile saline at the urethral sphincter. It was connected to the same urodynamic device through the same transducer set. Nerve stimulation was performed at the base of the so-called NVB (point A) and the rectal wall about 1 cm posterolateral, apart from the NVB (point B) (fig. 3). We then simultaneously measured ICP and IUP. Pressure at the 2 points was compared using the Mann-Whitney U test with statistical significance considered at $p < 0.05$.

RESULTS

With intraoperative electrical stimulation we measured ICP and IUP in 27 and 22 patients, respectively. In all cases we caused a significant increase.

The mean increase in ICP with stimulation was 9.8 ± 6.3 cm H_2O (range 2 to 22) at point A and 13.5 ± 7.3 cm H_2O (range 4 to 32) at point B. ICP at point B was significantly higher than at point A, ie the NVB ($p = 0.0240$). Of the 27 patients 20 (74.1%) had a higher measured ICP at point B than at point A. ICP began to increase gradually within 10 to 30 seconds after the initiation of stimulation. It attained a peak at the conclusion of stimulation and finally decreased gradually (fig. 4).

The mean increase in IUP with stimulation was 17.0 ± 9.4 cm H_2O (range 6 to 38) at point A and 11.2 ± 8.1 cm H_2O (range 0 to 35) at point B. IUP at point A was significantly higher than at point B ($p = 0.0353$). Of the 22 patients in whom we measured IUP 15 (68.2%) had higher IUP at point A than at point B. The IUP waveform was greatly different from that of ICP. IUP increased rapidly just after the initiation of stimulation and it decreased rapidly as soon as stimulation ended (fig. 4).

DISCUSSION

To our knowledge this is the first report of intraoperative simultaneous measurement of ICP and IUP in pelvic surgery. Our study suggests that the course of the cavernous nerves does not always agree with the surgically identified NVB. It exists on the rectal wall posterolateral, apart from the NVB rather than at the NVB. These results support our recent anatomical findings of the cavernous nerve course.[1,2] In addition, the surgically identified NVB contained the nerve fibers contributing to urinary continence.

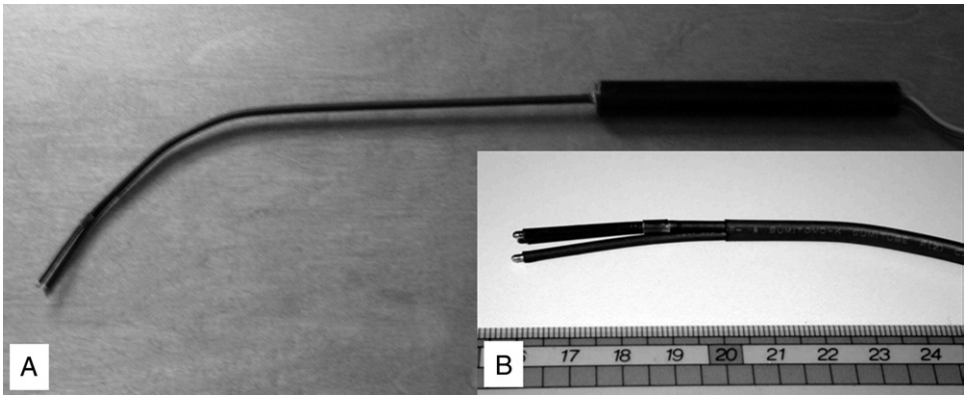

FIG. 2. *A*, original bipolar electrode used for intraoperative electrical stimulation. *B*, magnification shows 7 mm interval of 2 electrodes