Intraoperative Identification and Monitoring of the Somatic Nerves Critical to Potency Preservation during da Vinci® Prostatectomy

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Background

Since Walsh and Donker first introduced the anatomic nerve-sparing technique for retropubic radical prostatectomy[1] (RRP) in the treatment of clinically localized prostate cancer, the importance of minimizing damage to the neurovascular bundle (NVB) has been recognized as a critical element for the preservation of potency and urinary continence post-prostatectomy. Although originally demonstrated in open prostatectomy procedures, sparing the NVB as described by Walsh, et al, has been shown to be equally, and in some reported literature, more effective in preserving potency and continence outcomes when the laparoscopic or robotic-assisted radical prostatectomy (RARP) approach is utilized[2].

Studies of pelvic neuro-anatomy, however, have taught us autonomic innervation is only half the story when it comes to potency and continence preservation. The other half of the story is the somatic nerves that typically lie outside of the NVB and innervate the levator ani muscle (LA), the external urethral sphincter (EUS), the bulbospongiosus muscle (BM) and the ischiocavernosus muscle (IM) (table 1), all critical for both potency and continence. Therefore, to maximize preservation of potency and continence a technique involving both preservation of the parasympathetic nerves contained in the NVB and preservation of the somatic nerves that lie outside the NVB must be employed.

Importance of the Somatic Nerves

A review of the literature reveals that the parasympathetic and somatic nerve contribution to erectile function is well known and has been described as being associated with two different phases of penile erection - the *vascular phase* and *muscular phase* respectively[3]. The *vascular phase* is what is thought of most often and involves the parasympathetic mediated release of nitric oxide increasing arterial inflow into the corpora cavernosa and the resulting increase in penile tumescence and rigidity. This filling of the corpora also results in a reduction in venous outflow from the compression of the penile veins. During this phase intracavernous pressure (ICP) rises but does not exceed systolic blood pressure so full rigidity does not yet occur.

The *muscular phase* is responsible for the achievement of maximal tumescence and the rigidity necessary for intercourse. This phase is a somatic nerve mediated event wherein the contraction of the BM and IM compress the penile deep dorsal vein as well as the proximal part of the corpora cavernosa, maximizing the restriction of venous outflow and resulting in an ICP that is 3-5 times systolic pressure. It is this degree of ICP that is necessary to achieve the rigidity needed for vaginal penetration. Additionally, this somatic nerve mediated event, also pulls the penile shaft back to anchor it against the ischial tuberosity providing the support needed for vaginal penetration.[4]

The often described NVB-sparing technique, although successful in sparing the autonomic nerves involved in the initial filling of the corpora, does not necessarily spare the somatic nerves critical for reaching full penile rigidity or preserving urinary continence. These nerves stem from the pudendal nerve and include the perineal nerve and the muscular (deep) branch of the perineal nerve. Cadaveric studies have shown that these nerves typically lie outside the traditional NVB and the course and number of these somatic nerve branches vary significantly.[5, 6, 7] In addition, a recent study using an electroneurodiagnostic nerve monitoring system (the ProPep Nerve Monitoring System™) during robotic-assisted (da Vinci Surgical System) prostatectomies found the most common location of the perineal nerve that innervates the levator ani only occurred 50% of the time. These results clearly demonstrate relying on anatomic landmarks is not a reliable means of identifying the course of these critical somatic nerves.

The critical role these somatic nerves play in maintaining potency and continence, and the fact that their location is highly variable is a likely explanation as to why traditional NVB-sparing techniques often fail to result in satisfactory functional outcomes for patients. Studies report that 22% - 38% of patients are impotent and 3% - 10% are incontinent at 12 months despite having undergone “successful” NVB-sparing RARP surgery[2].

The purpose of this investigation was to determine if the ProPep Nerve Monitoring System, which previous studies have shown to be reliable in identifying the perineal nerve that innervates the levator ani muscle[9], could be used to identify the location of the muscular branch of the perineal nerve that innervates not only the EUS but also the IM and the BM, both known to be critical in potency preservation.

Table 1: Muscles Innervated by the Perineal Nerves

Muscle	Course and Insertion	Innervation	Main Action(s)
Bulbosponiosus	Surrounds lateral aspects of bulb of penis and most proximal part of body of penis, inserting into perineal membrane, dorsal aspect of corpora spongiosum and cavernosa, and fascia of bulb of penis.	Muscular (deep) branch of perineal nerve, branch of pudendal nerve (S2–S4).	Compresses bulb of penis to expel last drops of urine/semen. Assists erection by compressing outflow via deep dorsal vein and by pushing blood from bulb into body of penis.[3]
Ischiocavernosus	Embraces crus of penis, inserting onto inferior and medial aspects of crus and to perineal membrane medial to crus.	Muscular (deep) branch of perineal nerve, branch of pudendal nerve.	Maintains erection of penis by compressing deep dorsal vein and pushing blood from root of penis into body of penis. Increases intracavernosal pressure. Elevates penis past horizontal position and pulls penis against ischial tuberosity to assist vaginal penetration and thrusting.[5,6]
External urethral sphincter	Surrounds urethra superior to perineal membrane. Also ascends anterior aspect of prostate.	Muscular (deep) branch of perineal nerve, branch of pudendal nerve (S2–S4).	Compresses urethra to maintain urinary continence.
Levator ani	Forms the main part of the pelvic diaphragm, the cranial layer of the pelvic floor.	Perineal nerve; inferior rectal nerve, branches of pudendal nerve.	Controls opening and closing of the levator hiatus. By this means, plays a crucial role in the preservation of urinary and bowel continence.

Method

The ProPep Nerve Monitoring System is an FDA approved device for the real-time identification of nerves during laparoscopic and RARP surgery. Using this system, a cannula introducer was used to deliver thin, insulated, monopolar electrodes into the closed abdominal cavity during RARP (performed with the da Vinci Surgical System) in a way that did not affect the pneumoperitoneum and did not interfere with the performance of the surgical dissection. Once inside the abdominal cavity, the two electrodes were placed into the EUS on either side of the prostate and a ground electrode was placed into the external abdominal wall. A specially designed computer program and switching device were then used to deliver a low current (0.5-10 milliamps) stimulation signal through the da Vinci Maryland bipolar instrument. By transmitting the stimulation signal through the Maryland bipolar instrument, the surgeon was able to continue the operation uninterrupted and simply touch the tissue he was handling with the bipolar instrument after switching the instrument to stimulation mode with the switching device. When the tissue in question was touched with the bipolar, the stimulation signal was sent through the tissue and returned to the computer program through the previously placed monopolar electrodes. The computer then instantly analyzed the signal through a series of electronic filters and if the tissue being touched was close to the muscular branch of the perineal nerve (the nerve responsible for the innervation of the EUS, BM, and IM) a standard compound motor action potential was seen on the computer monitor (and in the surgeon console of the da Vinci Surgical System using the picture-in-picture feature of the da Vinci). The presence of this waveform instantly alerted the surgeon he was touching tissue close to this nerve allowing the surgeon to alter his dissection to selectively preserve it. Because the Maryland bipolar instrument could be instantly switched between cautery and stimulation mode, the location and integrity of the nerve could be continuously evaluated throughout the pedicle and apical dissection to constantly monitor trends and dynamic changes during critical portions of the procedure when this nerve was potentially at risk.

Results

The ProPep Nerve Monitoring System was able to successfully and reliably identify the otherwise invisible muscular branch of the perineal nerve. The location of the nerve generally varies from patient to patient and was typically found to be in close proximity to the apex of the prostate in a superficial position.

Conclusion

Nerve sparing during radical prostatectomy has traditionally focused on preservation of the parasympathetic nerves located within the NVB that are responsible for the vascular/filling phase of the erectile response. Studies have shown, however, that a somatic nerve (the muscular branch of the perineal nerve) not located within the NVB and found in variable locations around the apex of the prostate, drives the muscular phase of the erectile response. This nerve is responsible for the achievement of the full tumescence and rigidity needed for intercourse. Using the ProPep Nerve Monitoring Device, surgeons have demonstrated the ability to accurately, safely, and efficiently identify this critical nerve during RARP.

It is the authors' belief that the variability in the location of this critical somatic nerve, the resultant inability to predict its location based on anatomic landmarks, and the fact that it is located outside of the NVB makes the use of the ProPep Nerve Monitoring essential in locating this critical nerve to avoid potentially damaging it during both pedicle and apical dissection.

Further studies are warranted to explore the clinical benefits associated with the identification of this nerve during RARP.

References

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