J Gastrointest Surg (2010) 14:416–422
DOI 10.1007/s11605-009-0941-4

REVIEW ARTICLE

Autonomic Nerve Preservation During Rectal Cancer Resection

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Received: 30 April 2009 / Accepted: 20 May 2009 / Published online: 23 June 2009
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Keywords Rectal cancer resection · Autonomic nerve preservation · Total mesorectal excision

Introduction

Identification and preservation of pelvic autonomic nerves is important[1,2] during radical resection of a rectal cancer in order to reduce the risk of genitourinary dysfunction. Detailed anatomic dissections have highlighted the relationship between the pelvic autonomic nervous system (PANS) and other pelvic organs.[3] The superior hypogastric plexus (SHP) receives sympathetic contributions directly from the sympathetic trunk or via the inferior mesenteric ganglion, while the inferior hypogastric plexus (IHP) receives its major parasympathetic contribution (nervi erigentes) from the third sacral nerve root, with lesser contributions from the second and fourth.[3] Physiologic studies in animals and humans have demonstrated the importance of the parasympathetic nervous system in achieving and maintaining erection, while the sympathetic nervous system is important for ejaculation.[4] Both sympathetic and parasympathetic innervation of the urinary bladder influences continence via coordination of detrusor contraction and tone at the bladder neck.[5]

The introduction of total mesorectal excision (TME) in the operative treatment of rectal cancer has resulted in a decrease in local recurrence and improved survival.[6] TME, in conjunction with autonomic nerve preservation (ANP), has improved rates of postoperative genitourinary dysfunction.[1,7–9] In a report from our institution, rectal resection, incorporating the principles of TME and ANP, preserved the ability to have intercourse in 86% and 57% of men undergoing low anterior resection (LAR) and abdominoperineal resection (APR), respectively. The ability to achieve orgasm was maintained in 88% of men after LAR and 85% after APR. In women, postoperative sexual activity was continued in 86% of patients, while the ability to achieve orgasm was maintained in 91%.[10]

Because of the noted improvement in preserving bladder and sexual function following properly performed TME and ANP, surgical training programs have begun to incorporate these techniques into their curriculum. However, widespread implementation is still in its early stages. The purpose of this paper is, therefore, to present a detailed, step-by-step approach for TME and ANP during rectal cancer resection.

Material and Methods

After thoroughly inspecting the liver, peritoneum, and retroperitoneum for evidence of metastatic disease, attention is directed to the rectum and sigmoid colon. The sigmoid is rendered a midline structure by lysing congenital adhesions along the left pelvic sidewall. The redundancy of the sigmoid colon is assessed to determine the degree of left colon mobilization required if a primary anastomosis is to be performed. The retroperitoneum is entered sharply along the white line of Toldt and the retroperitoneal structures identified. At the level of the aortic bifurcation, the SHP lies posterior to the inferior mesenteric artery (IMA). Careful dissection between these two structures, while

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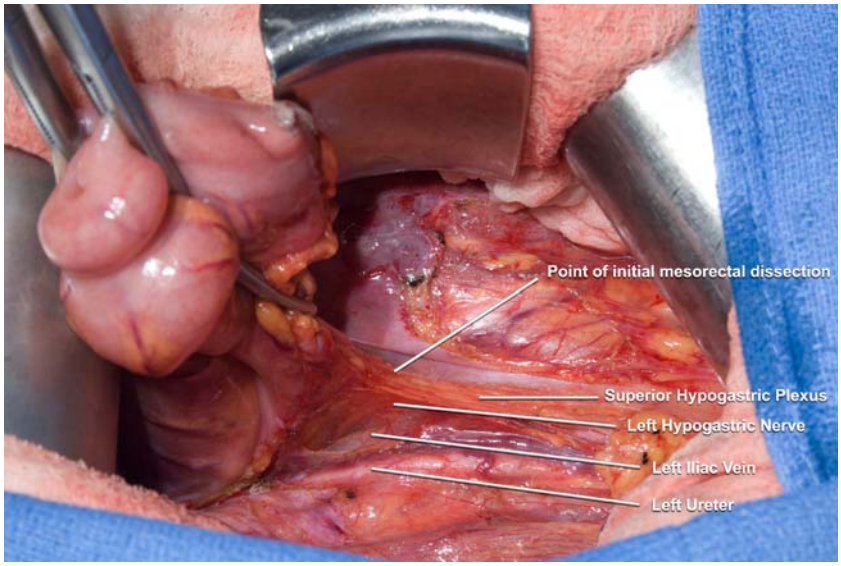


Figure 1 The distal sigmoid/proximal rectum is elevated anteriorly, exposing the aortic bifurcation and sacral promontory, with identification of the left ureter, left iliac vein, and superior hypogastric plexus. The hypogastric nerves may appear as an obvious discrete band of tissue or as multiple smaller bands.

retracting the rectosigmoid "toward the ceiling," allows the plexus to be "dropped down" to its normal anatomic position. The IMA and inferior mesenteric vein distal to the left colic vessels are skeletonized and ligated separately, when possible. The distal sigmoid colon is then transected using a GIA stapling device.

The distal sigmoid/proximal rectum is elevated anteriorly "toward the ceiling" exposing the aortic bifurcation and sacral promontory (Fig. 1), with early identification of the left ureter, left iliac vein, and SHP. The hypogastric nerves may appear as an obvious discrete band of tissue or as multiple smaller bands. Careful dissection of the sigmoid mesentery distally will lead to an avascular, areolar plane separating the mesorectal fascia propria from the presacral fascia (Fig. 2).

Insertion of a closed Mayo scissors into the space between the mesorectal fascia propria and presacral fascia aids in the identification of the paired hypogastric nerves (Fig. 3). Development of this plane is critical for a successful TME and ANP. The hypogastric nerves, which form a "wishbone-like" pattern as they exit the inferior aspect of the SHP in the midline, descend into the pelvis along the mesorectal fascia 1 to 2 cm medial to the ureters (Fig. 4). Further elevation of the specimen toward the patient's left may cause the hypogastric nerves to be "tented up" (Fig. 5), as they are often adherent to the mesorectal fascia. Careful dissection along the leading edge of the nerves will allow them to be peeled off of the specimen, similar to the peeling of onion skin. Caudal dissection in the posterior midline, while lifting the rectum "toward the ceiling," further develops the avascular areolar plane essential for identification of the sacral nerves (nervi erigentes; Fig. 6).

Anterior dissection begins with incision of Denonvellier's fascia. With the use of the St. Mark's retractor, this plane is developed until the seminal vesicles (in men; Fig. 7) or the

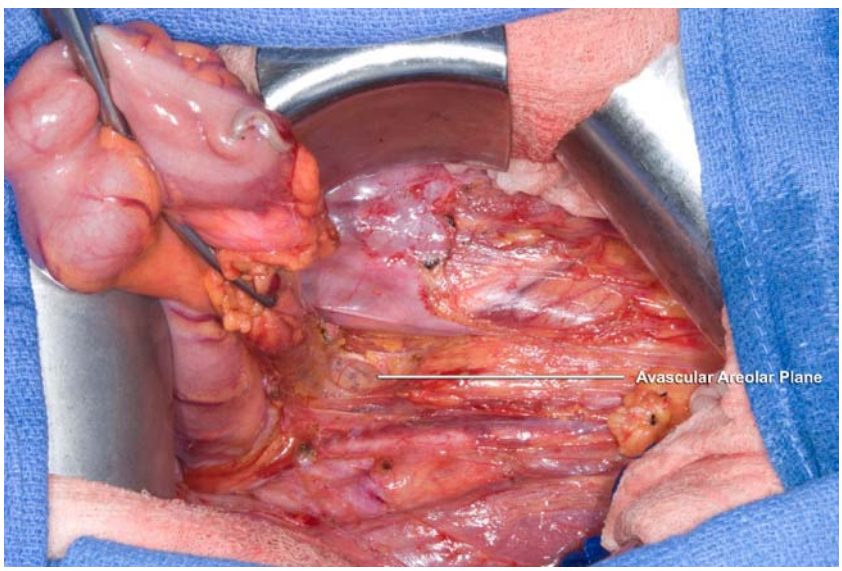


Figure 2 Careful dissection of the sigmoid mesentery distally results in an avascular, areolar plane separating the mesorectal fascia propria from the presacral fascia.

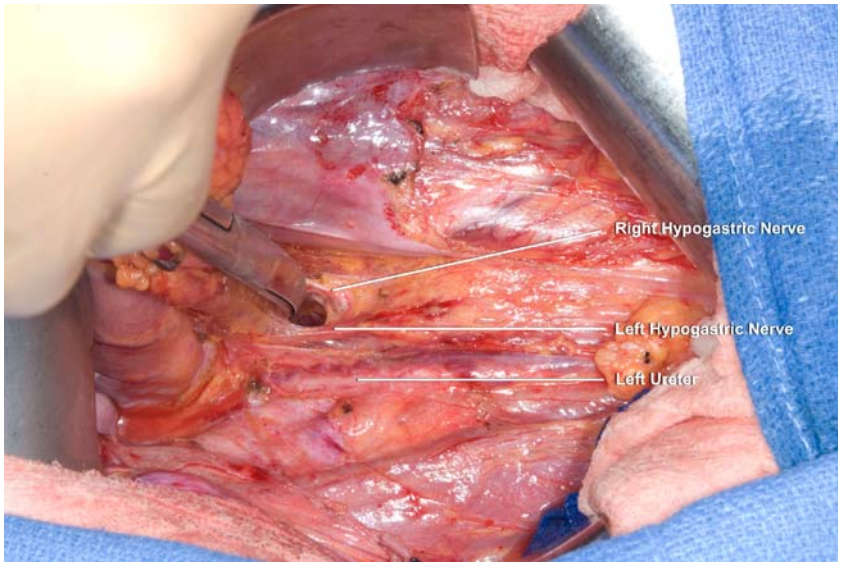


Figure 3 Insertion of closed Mayo scissors into the space between the mesorectal fascia propria and presacral fascia aids in identifying the paired hypogastric nerves.

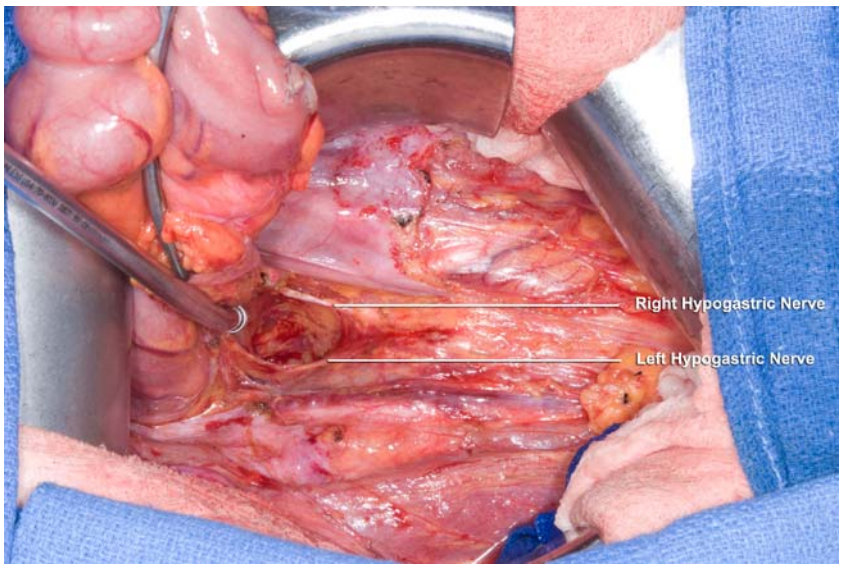


Figure 4 The hypogastric nerves form a wishbone-like pattern as they exit the inferior aspect of the superior hypogastric plexus in the midline. These nerves descend into the pelvis along the mesorectal fascia, 1 to 2 cm medial to the ureters.

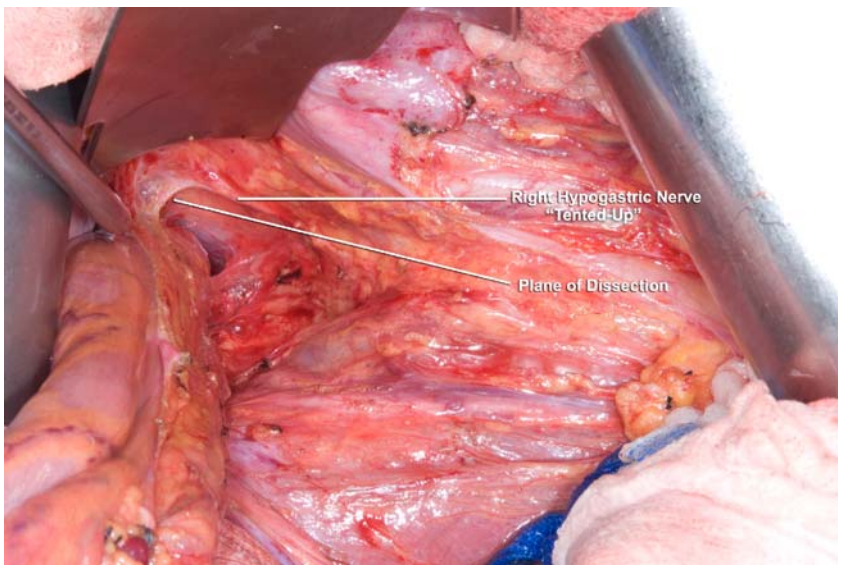


Figure 5 Further elevation of the specimen towards the patient's left may cause the hypogastric nerves to "tent up," as they often adhere to the mesorectal fascia.

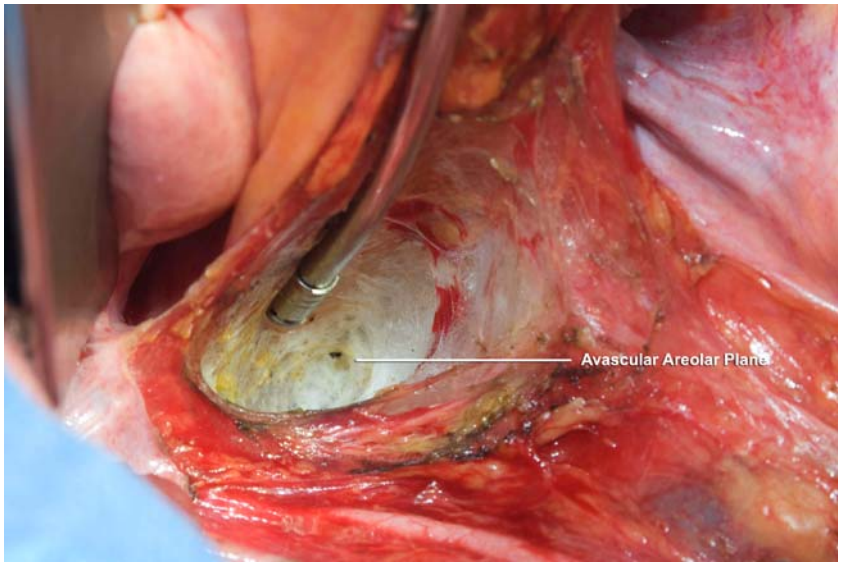


Figure 6 Careful dissection along the leading edge of the nerves permits them to be peeled off of the specimen, similar to peeling of onion skin. Caudal dissection in the posterior midline, while lifting the rectum "toward the ceiling," further develops the avascular areolar plane, which is essential for the identification of the sacral nerves (nervi erigentes).

rectovaginal septum (in women) is encountered. In men, care is taken not to injure the vascular capsule of the seminal vesicles, as the plane of dissection between it and the mesorectal fascia may not be clear initially.

The IHP is formed from the interdigitating fibers of the hypogastric (sympathetic) nerves and the sacral (parasympathetic) nerves. This structure appears as a fenestrated, rhomboid-like plate on the pelvic sidewall and is located anterolateral to the rectum and posterolateral to the seminal vesicles in men and corresponding zone in women.

As the mesorectal fascia is developed posterolaterally, the nervi erigentes are encountered, often adherent to the mesorectal fascia. These nerve fibers arise from the second, third, and fourth sacral nerve roots. Careful retraction of the specimen and dissection along the mesorectal fascia will facilitate release of the nerves and return them to their normal anatomic position along the piriformis muscle. This separation also mimics the peeling of onion skin (Fig. 8).

As distal dissection continues to the levator ani fascia, the mesorectum begins to taper and generally becomes absent 1–2 cm above the uppermost portion of the anorectal ring. For a LAR, transection of the rectum can then be performed at the appropriate level relative to the tumor and the specimen removed. A Veidenheimer non-crushing bowel clamp is placed distal to the lesion (as shown), and following a rectal washout, a linear stapler is used to transect the rectum at a point proximal enough to the vagina to avoid incorporation of vaginal tissue into the stapled anastomosis (Fig. 9). For patients treated with preoperative combined modality therapy, a distal margin of 1 cm may be adequate for complete tumor removal.[11] An APR can be performed at this point if a clear distal margin

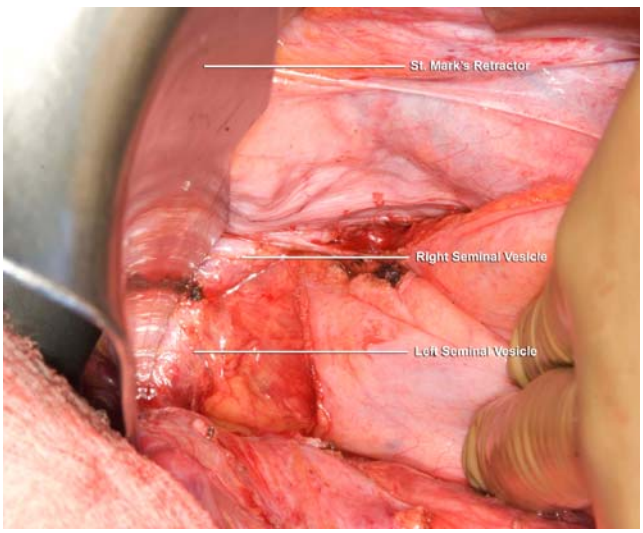


Figure 7 As the mesorectal fascia is developed posterolaterally, the nervi erigentes are encountered (often adherent to the mesorectal fascia). Meticulous retraction of the specimen and dissection along the mesorectal fascia facilitates release of the nerves, returning them to their normal anatomic position along the piriformis muscle. This separation mimics the peeling of onion skin.

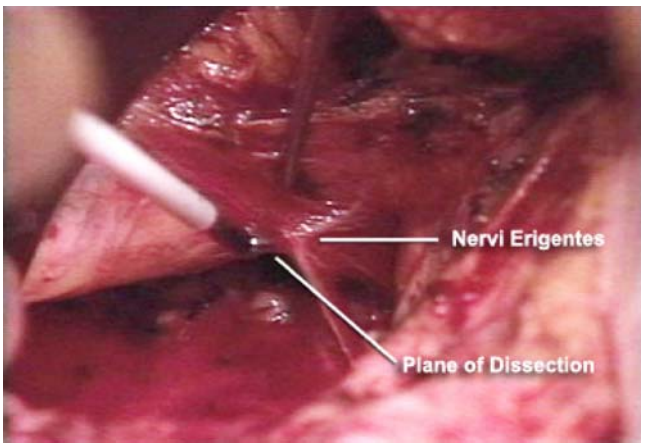


Figure 8 Anterior dissection begins with incision of Denonvellier's fascia. Using the St. Mark's retractor, this plane is developed until the seminal vesicles (in men) or rectovaginal septum (in women) is encountered.

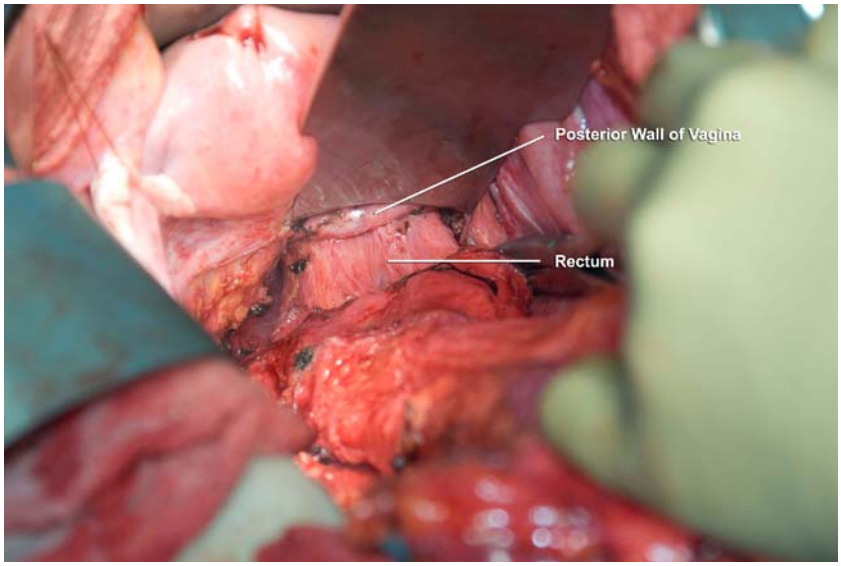


Figure 9 A Veidenheimer non-crushing bowel clamp is placed distal to the lesion. Following rectal washout, a linear stapler is used to transect the rectum at a point proximal enough to the vagina to avoid incorporation of vaginal tissue into the stapled anastomosis.

cannot be obtained or if involvement of the anal sphincter mechanism is suspected. The preserved autonomic nervous system can be visualized in its entirety upon removal of the specimen (Figs. 10 and 11). Adequacy of the TME can be judged by appreciation of an intact mesorectal fascia, which should be smooth and glistening upon gross inspection of the resected specimen (Fig. 12).

Discussion

Intraoperative Nerve Identification

Intraoperative identification and preservation of the PANS may reduce rates of postoperative genitourinary dysfunction.[8,12,13] In a study of 150 consecutive patients undergoing TME for rectal cancer, complete identification (by intraoperative visual inspection) of the PANS was achieved 72% of the time. In this study, risk factors contributing to incomplete nerve identification included previous pelvic surgery and intraoperative blood loss >1,000 mL. Patients who had complete identification of the PANS experienced a significant reduction in postoperative urinary dysfunction (4.5% versus 38.5%, $p<0.001$).[8]

Given the importance of nerve identification, some surgeons advocate the use of intraoperative nerve stimulation (INS) to aid in autonomic nerve identification and preservation. A recent study suggests that the use of INS with bladder manometry to intraoperatively identify parasympathetic nerves can improve rates of postoperative urinary dysfunction. Patients with evidence of unilateral or bilateral parasympathetic nerve damage had higher rates of long-term bladder catheterization after hospital discharge than those with confirmed bilateral preservation (33%

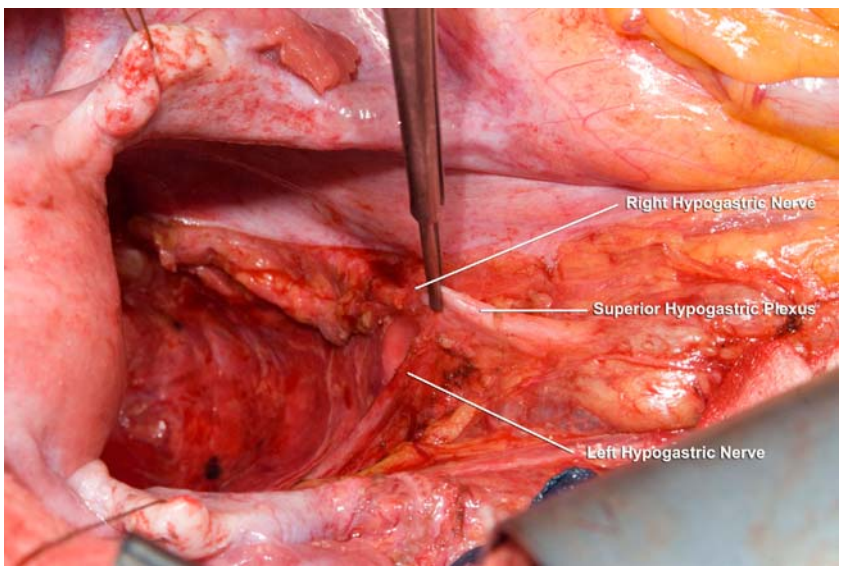


Figure 10 Upon removal of the specimen, the preserved autonomic nervous system can be visualized in its entirety.

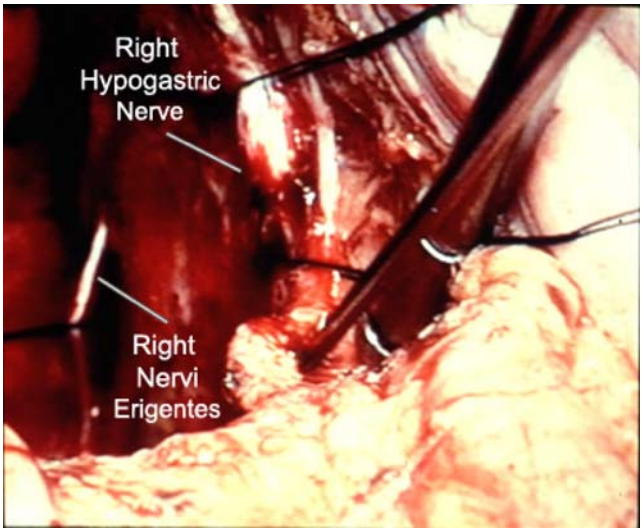


Figure 11 Upon removal of the specimen, the preserved autonomic nervous system can be visualized in its entirety.

versus 0%, $p=0.001$) and reported deterioration of postoperative urinary function (60% versus 4%, $p<0.001$). They also suggest that INS results are more sensitive than macroscopic assessment by the surgeon for identification of nerve damage.[12]

The CaverMap (Uromed Corp., Norwood, MA) nerve stimulator device, used to demonstrate penile tumescence in response to intraoperative parasympathetic nerve stimulation, may also enhance autonomic nerve identification and preservation.[14] In the Memorial Sloan–Kettering Cancer Center experience with this device, all 21 male study patients undergoing rectal cancer resection had at least unilateral response to INS. Sexual function (erection and orgasm) was normal in 18 (94.7%) patients surveyed 6 months postoperatively. In all of these patients nerve integrity was felt to be intact by the operating surgeon's visual assessment.[13]



Figure 12 Adequacy of a TME can be judged by appreciation of the intact mesorectal fascia. On gross inspection, the resected specimen should appear smooth and glistening.

Laparoscopic Rectal Resection with ANP

Laparoscopic techniques have been adopted for the operative treatment of rectal cancer. Studies comparing differences in rates of genitourinary dysfunction following laparoscopically assisted or open rectal cancer resections are limited. In 2002, one study reported no statistically significant difference in postoperative bladder dysfunction between patients undergoing laparoscopically assisted versus open mesorectal excision for rectal cancer. However, they did report significantly higher rates of impotence (33% versus 5%, $p=0.03$) and ejaculatory dysfunction (40% versus 5%, $p=0.01$) in men undergoing laparoscopic resection.[15] A larger, more recent study demonstrated similar rates of bladder dysfunction between patients undergoing either laparoscopic or open rectal resection, with trends toward worse overall sexual function and erectile function in men after laparoscopic resection.[16]

Conclusion

While ANP has gained acceptance in rectal cancer surgery, there are instances where its routine practice may not be justified. In patients with physical exam or radiologic findings suggestive of extensive pelvic disease, nerve preservation may not be technically feasible or oncologically sound. Direct tumor invasion of the autonomic nerves or presence of suspicious pelvic sidewall lymphadenopathy may require nerve sacrifice.

Genitourinary dysfunction results in significant morbidity when it occurs after rectal resection. Techniques for autonomic nerve identification and preservation, particularly during TME, can improve rates of postoperative sexual and urinary function.

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