ANATOMICAL ASPECT OF NERVE-PRESERVING SURGERY FOR RECTAL CANCER

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The outcome after resection for rectal cancers has improved following standardization of the surgical technique and the introduction of total mesorectal excision (TME) (1-4). In particular the TME technique has resulted in better local control and survival (5).

The existence of nodal metastases has been the most important overall prognostic factor in determining long-term survival rates (6). Adequate lymphadenectomy measured by analysis of at least 15 lymph nodes, correlates with improved survival, independent of stage, patient demographics, and tumor characteristics (7). However, surgical resection of the rectum with TME performed for rectal cancer has been connected with a high risk of loss of sexual function due to autonomic nerve damage. It is a common complication and may occur after radical pelvic surgery of all types: radical prostatectomy, radical cystoprostatectomy, anterior rectal resection and abdomino-perineal rectal resection. The pathophysiology of sexual dysfunction after pelvic surgery is unique because it can be a result of vascular or neurogenic factors alone, or a combination of both. Age, sex, type of surgery, and presence of malignant disease have all been shown to be associated with an increased risk of postoperative sexual dysfunction (8). In 1982, Walsh and Donker demonstrated that impotence following radical prostatectomy often occurred secondary to injury to the branches of the pelvic plexus that innervates the cavernous bodies of the penis, and they proposed minor modifications in the surgical procedure to avoid this complication (9). Later, these modifications were widely implemented during surgical procedures involving radical prostatectomy (10) and cystoprostatectomy (11).

The sphincter-saving procedures also diminished the risk of postoperative sexual dysfunctions in abdomino-perineal resection (APR). The impotence rates after APR reported in the literature vary from 15% to 92%, and sexual dysfunction rates after all rectal cancer surgeries range between 10% and 60% (12).

Most surgeons are currently performing TME with preservation of the neurovascular bundles, a technique which has been shown to be effective in reducing postoperative sexual dysfunction rates. In 1997 Enker et al. reported that APR performed in accordance with the principles of TME and autonomic nerve preservation results in preserving both sexual and urinary functions (13). Their study showed that 57% of patients undergoing APR and 85% undergoing sphincter preserving operations maintained their urinary and sexual functions (14). With the increasing popularity of laparoscopy some surgeons perform laparoscopic assisted TME. Quah reported that sexual dysfunction rates in men were higher after laparoscopic surgery than after open surgery, while the rates of sexual dysfunctions in women stayed the same for both techniques (15). However, owing to the paucity of reports...
in the literature, it may be too early to reach a conclusion regarding sexual function following laparoscopic TME.

This manuscript outlines the anatomic considerations necessary for autonomic nerve preservation and the potential application of this knowledge to rectal resection. The mechanisms and the most common locations of nerve injury have also been analyzed.

ANATOMY

The parasympathetic preganglionic fibers arising from the sacral roots of S2, S3 and S4 emerge through the pelvic sacral foramina to form the nervi erigentes. They pierce the endopelvic fascia from behind to enter the plane of the pelvic plexus. They pass through the inferior hypogastric plexus and then join with the sympathetic hypogastric nerve in a Y-shaped connection to form the pelvic plexus.

The sympathetic nerves to the pelvic reproductive organs arise in the lower thoracic and upper lumbar spinal segments. The superior hypogastric plexus is situated just below the aortic bifurcation. Above the bifurcation it is continuous with the sympathetic trunks and its fibers exit caudally as the hypogastric nerves. These nerves then unite to form the superior and inferior hypogastric (pelvic) plexuses and lie immediately beneath the peritoneum anterior to and on either side of the aorta. Just below the sacral promontory, the superior hypogastric plexus divides to form the inferior hypogastric plexus. In females, the inferior hypogastric plexus passes inferiorly within the hollow of the sacrum where the fibers are directed toward the uterosacral ligaments close to the rectal ampulla. At this level the nerves contain purely sympathetic fibers. These fibers, along with the nervi erigentes and the sacral sympathetic chain, form the pelvic plexus. Branches from the pelvic plexus to the rectum run from lateral to medial immediately under the peritoneum. Nerves leading from the plexus to the bladder and to the sexual organs run deeper and are inclined more anteriorly. The cavernous nerves run in neurovascular bundles at the lateral border of Denonvilliers’ fascia (16). These nerves eventually run anterior to Denonvilliers’ fascia at the posterolateral border of the apex and base of the prostate, but are closely related to the anterior wall of the rectum (fig. 1).

The pelvic plexus is located between the rectum and postero-lateral portion of the bladder. The nerve fibers that comprise the post-ganglionic nerves lie just below the peritoneal reflection on either side of the rectum and in close proximity to it. The pelvic plexus is a network of nerves forming a sheet of neural tissue that lies laterally in the pelvis, lateral to the lower third of the rectum. The lateral ligament of the rectum arises from the endopelvic fascia of the side wall and inclines antero-medially as it approaches the rectum. The fibers from the pelvic plexus travel obliquely along the base of the broad ligament, and its fibers continue on to innervate the pelvic organs. In males fibers of the inferior hypogastric plexus pass downward and anteriorly just below the peritoneum adjacent to the rectum. These fibers continue around the recto-vesical pouch. Fibers of the inferior hypogastric and pelvic plexus pass immediately adjacent to the anterolateral wall of the rectum. The nerves are embedded in a layer of loose areolar tissue that frequently contains many lymph nodes. These fibers lie just beneath the peritoneum overlying the rectum. At this point the pelvic plexus gives rise to the periprostatic plexus. The periprostatic plexus contains nerve fibers from both the nervi erigentes and the inferior hypogastric nerves. The nervi erigentes innervate and

![Fig. 1. Hypogastric nerve (held in tweezers) cadaveric preparation](image-url)
cause dilatation of the internal pudendal artery in both men and women and also the arteries of the corpora cavernosa in men. Fibers from the periprostatic plexus course through the prostatic capsule, intermingling with the prostatic venous plexus, and then innervate the corpora cavernosa, seminal vesicles, and the prostate. The pudendal nerves also have motor and sensory components that are distributed to the external sphincter of the bladder and supply sensory perception to the pelvis and perineum in both sexes (17) (fig. 2).

COMMON SITES OF AUTONOMIC NERVES INJURY

Autonomic denervation may appear during specific surgical procedures by arterial ligation, tumor excision and mainly by lymphangiectomy. It is essential that attention is paid to autonomic nerve preservation during lymphadenectomy especially in locations where lymphatic tissue and autonomic innervation run in unison.

Lymphatics of the rectum

Superior and inferior mesenteric nodes are anterior to the abdominal aorta near the origins of these arteries. They are preterminal groups for the alimentary canal from the duodenojejunal flexure to the upper anal canal and collect from outlying groups, including the mesenteric, ileocolic, colonic and pararectal nodes. They discharge into the coeliac nodes and then into the intestinal trunks confluence and thoracic duct. Pararectal nodes are in contact with the rectal muscular wall, draining to an intermediate group around the superior rectal artery. From the intermediate group they drain to nodes near the origin of the inferior mesenteric. Others drain to nodes at the bifurcation of the common iliac artery.

Lymphatic drainage of the rectum and anal canal

Lymphatic vessels emerging from the walls of the upper half to upper two-thirds of the rectum ascend with the superior rectal vessels. They follow a path through the pararectal nodes, to nodes in the lower sigmoid me-socolon and along the inferior mesenteric artery. From the lower half of the rectum and the anal canal, above its mucocutaneous junction, lymph vessels ascend through the wall to accompany the middle rectal vessels to the internal iliac nodes. Some are said to traverse the levator and into the ischorectal fossa to accompany the inferior rectal and internal pudendal vessels to the internal iliac nodes. Lymphatics of the anal canal below the mucocutaneous junction descend to the anal margin, curving laterally to reach the most superficial inguinal nodes.

INJURY LOCATIONS

Mechanical injuries to autonomic nerves have different effects in men and women. Parasympathetic denervation in men leads to impotence through a lack of adequate erection. Sympathetic damage in men produces a failure to achieve ejaculation. In women parasympathetic denervation is the cause of dyspareunia and vaginal dryness. Presently, there is insufficient data to assess the effect of sympathetic denervation in women. Autonomic nerves may be damaged during surgical operation at a number of points, as shown in tab. 1.

Sympathetic nerves are at risk of isolated damage as high as the origin of the inferior mesenteric artery of the aorta. Hypogastric nerves may also be damaged by the ligation of the superior rectal artery and at the pelvic
brim during lymphadenectomy. However, lateral pelvic sidewall lymphadenectomy and sacral lymphadenectomy may produce sympathetic as well as parasympathetic damage. An important site of sympathetic and parasympathetic denervation appears to be the delicate fibers that pass anterolaterally to the rectum on their way through the urogenital diaphragm to the corpora of the prostate. In support of this contention, the rate of impotence appears to be higher in low anterior resections, high anterior resections and even higher in abdomino-perineal excisions. The nerves at that level are easily visible and can be spared by careful preparation (fig. 3).

In conclusion, it is not only oncological radicality that plays an important role in the treatment of rectal cancer, but also quality of life after the surgical procedure. Good understanding of the anatomy of the pelvic nerves can reduce the risk of nerve damage and the possibility of functional complications.

Table 1. Autonomic nerves injury (effects and location)

<table>
<thead>
<tr>
<th>Effect in men</th>
<th>Effect in women</th>
<th>Aorta</th>
<th>Pelvic brim</th>
<th>Sacrum</th>
<th>Lateral pelvic sidewall</th>
<th>The base of the prostate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sympathetic</td>
<td>ejaculation</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Parasympathetic</td>
<td>erection</td>
<td>lubrication</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
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Fig. 3. Autonomic fibers at the base of prostate (cadaver)

REFERENCES


