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REVIEW

Mesorectal excision: Surgical anatomy of the rectum, mesorectum, and pelvic fascia and nerves and clinical relevance

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Abstract

Biologic behavior and management of rectal cancer differ significantly from that of colon cancer. The surgical treatment is challenging since the rectum has dual arterial blood supply and venous drainage, extensive lymphatic drainage and is located in a bony pelvic in close proximity to urogenital and neurovascular structures that are invested with intricate fascial covering. The rectum is encased by fatty lymphovascular tissue (mesorectum) that is surrounded by perirectal fascia that act as barrier to the spread of the cancer and constitute the surgical circumferential margin. Locoregional recurrence after rectal cancer surgery is influenced by tumor-related factors and adequacy of the resection. Local recurrence is associated with incomplete excision of circumferential margin, violation of perirectal fascia, transmesorectal dissection, presence of isolated deposits in the mesorectum and tumor in regional lymph nodes and incomplete lymph node clearance. Hence to eradicate the primary rectal tumor and control regional disease, the rectum, first area of lymph node drainage and surrounding tissue must be completely excised while maintaining an intact fascial envelope around the rectum and preserving surrounding structures. This is achieved with extrafascial dissection and removal of the entire mesorectum including the portion distal to the tumor (total mesorectal excision) within its enveloping fascia as an intact unit. Total mesorectal excision is the standard of care surgical treatment of mid and low rectal cancer and can be performed in conjunction with low anterior resection, abdominoperineal resection, extralevator abdominoperineal resection, and extraregional dissection. To accomplish such a resection, thorough knowledge of the surgical anatomy of the rectum and pelvic structures and fascial planes is paramount.

Key words: Mesorectum; Pelvic fascia; Mesorectal excision

Core tip: Radical resection of rectal cancer entails removal of the rectum with its fascia as an intact unit while preserving surrounding vital structures. The procedure is technically challenging because of the complex multilayered pelvic fascia and intimate

relationship between the rectum and vital surrounding structures. Despite the clear-cut "text book" description of surgical technique and straightforward manner of handling different structures in the pelvis, there are many variations and contradictory accounts reported in the literature as to the nature, anatomy and significance of some of the structures, proper plane of dissection, and the optimal technique to achieve oncological resection while decreasing urogenital and bowel dysfunction.

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INTRODUCTION

Colorectal cancer is the most common gastrointestinal malignancy in the United States and the second leading cause of death in the western countries. About 30% of the cancers are located in the rectum and 40000-42500 new cases of rectal cancer are diagnosed in the United States every year. The biologic behaviour and management of rectal cancer differ from colon cancer since it arises from an organ that has dual arterial supply and venous drainage and complex and extensive lymphatic drainage and is located in the pelvic in close proximity to the anal sphincter complex, surrounded by major neurovascular structures and constrained by the bony pelvis. Surgery remains the mainstay treatment modality. The primary goals of treatment are to cure the cancer, reduce local recurrence, maximize disease-free survival, maintain function, and optimize quality of life (Qol). Mortality of rectal cancer is related to metastatic spread prior to resection and local recurrence after resection. About 50%-75% of local recurrences are confined to the pelvis (locoreginal)[1]. The 5-year survival with local recurrence is < 5% and Qol is severely impaired by symptoms associated with local recurrence[2,3]. Locoregional recurrence is influenced by surgery-related factors and tumor-related factors and one of the most important surgery-related factors is adequacy of the resection.

Treatment of rectal cancer continues to evolve and change is brought about by improved preoperative staging of the cancer, better understanding of the biologic behavior of the cancer, development of new instruments and the introduction of new and effective chemotherapeutic agents. The surgical resection has also become a more refined and accurate procedure as a result of better understanding of the surgical anatomy of the rectum and endopelvic fascia, topographic relationship between the rectum and surrounding structures and adherence to the principles of oncologic surgery. As a result, there has been a reduction in the number of locoregional recurrences, increased utility of reconstructive surgery and minimally invasive laparoscopic and robotic surgery, and decreased bowel, urinary and sexual dysfunction.

DISCUSSION

The rectum

Surgical anatomy: The rectum resides in the pelvis and extends from the rectosigmoid junction to the anal canal. It commences where the tenia coli of the sigmoid colon fuse to form a single continuous longitudinal muscle coat around the rectum. According to anatomists, it begins at third sacral vertebra (S3) and according to surgeons at the sacral promontory[4]. The junction of the rectum with the anal canal is demarcated by anorectal ring where the puborectalis muscle blends with the deep external anal sphincter (EAS). Although often described to measure 13-18 cm in length, the rectum is situated within the true pelvis (the part of the pelvis located distal to a line drawn from the sacral promontory to the symphysis pubis) is rarely 15 cm long[5]. The rectum has intraperitoneal and extraperitoneal components and is divided into upper, middle and lower parts. The upper rectum is intraperitoneal surrounded by peritoneum except for a small segment posteriorly where the superior hemorrhoidal vessels descend through the mesorectum to supply the rectum. It is situated 10-15 cm from the anal verge. The middle rectum is covered by peritoneum only anteriorly and is situated 6-10 cm from the anal verge. The lower rectum is extraperitoneal and situated 5 cm from the anal verge[5]. The peritoneum covering the upper third of the rectum is reflected onto the pelvic sidewalls to form the pararectal fossa and onto the seminal vesicles in the male and vagina in the female to form the rectovesical and rectovaginal pouch respectively.

The rectum possesses an outer longitudinal and inner circular smooth muscle layer. The outer surface lacks the appendices epiploica and the inner surface lacks the haustra found in the sigmoid colon. The outer longitudinal layer mixes with some of the fibers of the levator ani and forms the conjoint longitudinal muscle. This muscle extends in the intersphincteric plane between the internal anal sphincter (IAS) and EAS and sends fibers that traverse the EAS, ischioanal space, and the IAS. The EAS is a striated muscle that surrounds the IAS. The deepest portion of the EAS is intimately related to the puborectalis muscle and the superficial part is attached to the anococcygeal ligament posteriorly and perineal body anteriorly. The outer surface of the rectum has three lateral curves and the luminal surface has three folds that constitute the valves of Houston. The middle valve (Kohlrasch's valve) is the most consistent and marks the anterior peritoneal reflection that is about 7-9 cm above the anal verge in men and 5-7.5 cm in women.

The rectum is surrounded with the mesorectum that is in turn wrapped by the perirectal fascia. The intraperitoneal part of the rectum is related to the uterine appendages laterally and the upper part of the vagina in females anteriorly. Loops of small bowel, sigmoid colon and the ovaries and fallopian tubes often reside in the rectovesical or rectouterine recess. The lower two thirds of the rectum follow the curve of the sacral hollow. The extra-peritoneal part of the rectum is related to the sacrum and the coccyx posteriorly, pararectal space laterally, and the urogenital organs anteriorly.

The rectum is surrounded with potential spaces: pararectal, retrorectal and supralevator. The pararectal space is an extraperitoneal space on the lateral side of the rectum and composed of loose and partly dense connective tissue. It is bound superiorly by the peritoneum, rectum medially, pelvic side wall and obturator internus laterally, and the levator ani inferiorly. The supralevator space is located between the peritoneum superiorly, levator inferiorly, rectum medially and obturator fascia laterally. The retrorectal space is located between the fascia propria of the rectum anteriorly, presacral fascia posteriorly, rectosacral ligament inferiorly, and lateral rectal ligaments laterally. The retrorectal space is continuous with the retroperitoneum superiorly.

Clinical relevance: Treatment of rectal cancer depends on its location in the rectum and extent of involvement of rectal wall and regional lymph nodes (LN) by primary tumor.

The level of the tumor in the rectum can be determined clinically in relation to the anorectal ring and endoscopically in relation to the rectal valves. The anorectal ring is felt on rectal examination as a muscular band that corresponds to the proximal shelf of the anal canal[5]. Kohlrasch's valve marks the anterior peritoneal reflection that is 7-9 cm above the anal verge in men and 5-7.5 cm in women. Cancers of the intraperitoneal rectum (upper third) behave like cancers of the colon with regards to recurrence patterns and prognosis but cancers of the extraperitoneal rectum constitute the rectum from the oncologic standpoint. Cancers of the upper and proximal part of the middle rectum are treated with an anterior resection and a straight colorectal anastomosis. Cancers of the distal middle and lower rectum are treated with abdominoperineal resection (APR) and end colostomy, sphincter sparing procedure or intersphincteric resection. For distal rectal cancer, sphincter sparing is possible if the lower edge of the tumor is at least 3 cm from the anorectal ring so as to allow a 2 cm distal magin. A 2 cm is considered adequate since any distal intramural spread is almost always within 1.5 cm of the primary and only 4%-10% have spread > 1 cm and any spread beyond 1.5 cm is associated with high grade or widely metastatic tumors[6-9]. A 1 cm margin is considered adequate for tumors < 5 cm from the anal verge especially when neoadjuvant chemoradiotherapy is used[10]. With sphincter-sparing procedure, an extended or ultralow anterior resection with a straight colo- or colonic-pouch-low rectal/anal anastomosis is performed. The coloanal anastomosis may be performed hand sewn transanally at the dendate line after excision of the mucosa from the dentate line to the anorectal junction or stapled at the anorectal junction. With intersphincteric resection, dissection is performed in the intersphincteric plane starting at the intersphincteric groove with partial or complete removal of the internal sphincter and a hand-sewn anastomosis performed transanally.

Select cases of early stage rectal cancer (Stage Ⅰ) may be treated with conservative resection, *i.e.*, local excison, either through a posterior approach (Kraske posterior proctotomy and York-Mason trans-sphincteric excision) or per anal approach (Park's per anal excision)[11-13]. The posterior approach is an established procedure but not frequently practiced because of associated morbidity and the advent of newer, less invasive and refined transanal procedures, *i.e.*, transanal endoscopic microresection (TEM), transanal minimally invasive surgery (TAMIS) and Robotic-TEM. With peranal excision (Parks' transanal local excision) the tumor is excised under direct visualization through the anal orifice. The procedure is limited to T1 or T2 small tumors (< 3-4 cm or < 30% of the circumference of rectal lumen), 8-10 cm from the anal verge and not fixed to the levator muscle. With TEM, TAMIS and Robotic-TEM, more proximal, larger or advanced lesions can be excised.

PELVIC FASCIA AND MESORECTUM

Surgical anatomy

Pelvic fascia: The pelvic fascia is associated with the pelvic wall and viscera and fills spaces between pelvic viscera and is continuous at the pelvic brim with the extraperitoneal abdominal fascia.

In pelvic dissection for low rectal cancer, Takahashi *et al*[14] described the "visceral and parietal endopelvic fasciae" as downward extension from the fascia in retroperitoneal space in the abdomen. In the abdomen, the visceral fascia runs under the peritoneum anterior to the aorta and cava, extends into the pelvis and envelops the rectum and mesorectum as the visceral endopelvic fascia. The parietal fascia runs posterior to the aorta and cava and extends into the pelvis along the entire pelvic wall as the parietal endopelvic fascia. In the true pelvis posteriorly, there is a potenial space between the two fasciae filled with loose areolar tissue and devoid of vessels and nerves[14]. Anteriorly at the level of the peritoneal reflection, the visceral endopelvic fascia envelops Denonvilliers' fascia on the anterior side of the rectum. Below the peritoneal reflection the circular continuity of the visceral endopelvic fascia is interrupted laterally by the presence of the lateral rectal ligaments and pelvic nerve fibers that arise from S3 and S4 foramina. At the distal side of the lateral ligaments is a free space that extends between the endopelvic fasciae to the levator ani muscles[14].

Others divide the pelvic fascial arrangement into thin connective tissue layers covering surfaces of organs and connective tissue condensations of varying thickness that separate compartments. The parietal endopelvic fascia is described as a multilayered fascial tissue condensation that contain the hypogastric nerves together with the pelvic splanchnic nerves (PSN)[15-17]. Posteriorly, the fascia and embedded nerves can be easily separated as a compact structure from the anterior surface of the sacrum to uncover another thin fascia in front of the sacrum[16]. The fascia fuses with mesorectal fascia in the mid line posteriorly at the level of S4 creating a connective tissue bridge that can be quite dense and corresponds to the rectosacral ligament[17,18]. Antero-laterally, thin connective tissue continuations spread out medially from the fascia to interweave with the lateral extension of Denonvilliers' fascia that separates the rectum from the prostate and vagina[16]. The parietal endopelvic fascia exhibits an inner and outer lamella[15,19]. The continuity of the 2 lamellae varies, as does the thickness of tissue between them. The inner lamella envelops the mesorectal fascia posteriorly and laterally, thus confining the retrorectal space. Laterally the inner lamella and mesorectal fascia fuse thus the retrorectal space does not extend anterolateral[14,16]. The outer lamella extends between the iliac vessels on both sides and borders the presacral fascia posteriorly creating another plane that could be mistaken for the retrorectal space[19]. Laterally, the outer lamella cannot be delineated as distinctly as posteriorly since it is pierced by the PSN and blood vessels. The PSN emerging from the sacral roots and the hypogastric nerves originating from the superior hypogastric plexus, join the inferior pelvic plexus within the parietal pelvic fascia from and send several fine branches that diverge in a fan-like pattern towards the distal ureter, vas deferens, seminal vesicles, urinary bladder, prostate and the rectum[16]. The autonomic nerve fibers innervating the rectum pierce the lateral aspect of the fascia and enter the rectal wall (T-junction)[16,20].

Presacral fascia: On the posterior abdominal wall, a connective tissue sheath associated with the kidneys, ureters and genital vessels (urogenital fascia) descends into the pelvis below the promontory of the sacrum for few cm in front of S1, rarely S2, where it ends anterior to presacral fascia sometimes as a conspicuous border arched between the hypogastric nerves[21,22]. The urogenital fascia invests the ureters always lateral to the hypogastric nerves on the pelvic wall under the peritoneum of the pararectal fossa[21,22].

The presacral fascia (retrorectal fascia, Waldeyer's fascia) originates from S2 and S3 as thickened part of the parietal endopelvic fascia[23,24]. In the mid line posteriorly it descends in front of the sacrum, coccyx, the middle sacral artery and presacral veins, fuses with the periosteum of the sacrum and coccyx and covers the piriformis muscle. At the sacral foramina it ensheathes the nervi erigentes. The presacral fascia and the interface with the backside of the parietal pelvic fascia mimic the retrorectal space and the posterior aspect of the mesorectum[16]. The lateral margin of the fascia is connected with loose tissue to the sheath around the PSN[25]. At the level of S3-S4, the fascia sends extensions, the rectosacral ligament (posterior rectal ligament), in an anterior inferior direction or may become adherent to the fascia propria of the rectum 3-5 cm above the anorectal ring[16,18,21,25-27]. Sato *et al*[26] noted that the rectosacral ligament varies from several layers of parietal fascia passing forward and attaching to fascia propria as a "ligament" to a diffuse adherence between the two fasciae. It separates the retrorectal space from the subfascial space[21]. The composition of the rectosacral ligament is not well studied. Although few vessels and nerves are identified in cadavers, the rectosacral fascia does not contain any significant vessels. Distal to the rectosacral ligament between the fascia propria of the rectum and presacral fascia, lays the horizontal last 2-3 cm of the rectum[21]. The presacral fascia in that area becomes thinner and fascia propria thicker and may be composed of two layers.

Perirectal fascia: The rectum is "cocooned" within the mesorectum that is surrounded by perirectal fascia (or fascia propria) that fixes it in the pelvis and isolates it from the other adjacent pelvic organs. Fascia propria is an extension of the abdominal retroperitoneal visceral fascia or represents an upward capsular extension from the superior fascia of the pelvic floor that reflects off the pelvic sidewalls to become continuous with the subperitoneal loose connective tissues of the pelvis covering the pelvic floor musculature[14,28].

Thomas Jonnesco[29] (1901) was the first to describe the perirectal fascia as a strong, nonyielding, no more than 2-3 mm thick serofibrous sheath that encapsulated the rectum, fat, and the superior hemorrhoidal vessels and its branches and tributaries.

Bisset *et al*[27] likened fascia propria to a "sock", a shiny continuous sheath that completely surrounded the rectum and the surrounding mesorectum fusing with the peritoneum where the peritoneum reflects off the rectum. The sheath extended cranially around the rectum as far as the upper limit of the ampulla and continued into the retroperitoneum in a plane posterior to the inferior mesenteric vessels. Caudally it adhered to the presacral fascia opposite the S4 as the rectosacral ligament. Most distally as the mesorectum thinned out to the point where the fascia propria adhered intimately to the longitudinal muscle layer of the rectum at the anorectal junction. Anteriorly the fascia did not extend as high but rather merged with the peritoneum reflection (rectovesical or rectovaginal pouch). Below the peritoneal reflection, the fascia lied immediately posterior to the fascia of Denonvilliers' and could not be demonstrated as a separate layer.

At the lateral border of the pouch it fused with the submesothelial fibrous layer of the peritoneum lateral to the rectum and thin connective tissue continuation spread out medially to interweave with lateral extensions of the Denonvilliers' fascia. On histologic and electron microscopy examination, fascia propria appeared as a multilayered structure (in 80% of cases) of variable thickness ranging from 20 to 1000 um with an average thickness (measured *in vitro*) of about 150 um made up of multiple bundles of collagen fibers. It appeared thicker posteriorly than anteriorly. Anteriorly the fascia could not be demonstrated as a separate layer.

Mesorectum: The mesentery of the rectum, *i.e.*, mesorectum, is the perirectal fatty lymphovascular tissue extending the length of the rectum[5]. The mesorectum encases the rectum as a thick cushion mainly posteriorly and laterally. Posteriorly it has a characteristic bilobed appearance[21,27,28,30]. Inferiorly it thins out and tapers down to the anorectal junction. The mesorectum is enclosed with the perirectal fascia[27].

The superior, middle and inferior hemorrhoidal arteries (SHA, MHA and IHA respectively) provide blood supply to the rectum and anal canal. The SHA is a direct continuation of the inferior mesenteric artery (IMA) that arises from the anterior surface of the aorta at the undersurface of the third part of the duodenum. It descends in the mesosigmoid colon to the level of S3 where it bifurcates into right and left branches then further divides into anterior and posterior branches. These branches penetrate rectal wall into the submucosa and descend in that plane to the level of columns of Morgagni. The MHA shows great variability in its origin, presence, size and number. The artery may arise from the anterior division of the internal iliac artery (IIA) or have an anomalous origin from the inferior vesicle, inferior gluteal, or internal pudendal artery[26,31,32]. The MHA is identified in 12% to 100% of cases depending on size of vessel described[26,31,32]. The artery is bilaterally present in 14%-48% of cases and unilateral in 24%-31%[26,33]. When present bilaterally the origin is not always identical on both sides[32]. The artery is long and tortuous, passes down and medially below the peritoneal reflection on top the levator muscle, pierces the pelvic plexus during its course, enters the anterolateral aspect of the rectum between the superior and inferior rectal branches of the pelvic plexus, and gives several branches to the muscular coat of the lower rectum and submucosal plexus[25,32,33]. The size of the artery is variable and the point of insertion in rectum is 5-6 cm from the anus[25,32,33]. Immediately at the insertion, it is anterolateral to the rectum related anteriorly to the prostate and seminal vesicle or upper vagina. It then passes obliquely and medially traversing Denonvilliers' fascia[25,31,33,34]. The branching PSN arise posterior to the origin of the MHA and run in an anteromedial direction and reach the rectum at a similar height above the pelvic floor as the MHA. The MHA is closer to the pelvic floor and crosses the mesorectum independent of any structure. The vessel does not go through the lateral rectal ligaments and only accessory branches are found in 25% of cases and pass through the lateral ligaments[31,35]. By injection technique, the superior rectal field is filled by virtue of anastomotic connections with branches of MHA, the anastomosis between the SHA and MHA occurs both in the wall and extramurally, and connections between the SHA and MHA with the IHA are not demonstrable[31]. Since the presence of the MHA is variable and mostly is absent and its blood goes mainly to the muscle of the rectum and mostly to the prostate, its contribution to the viability of the rectum is considered insignificant[32]. The IHA is a branch of the anterior division of the internal pudendal artery that is a branch of the IIA and is mainly extrapelvic. The endopelvic fascia invests it as it passes out of the pelvis below the piriformis muscle through the greater sciatic foramina. It courses for a short distance in the buttocks then reenters the pelvis after passing over the sacrospinous ligament to enter Alcock's canal in the lateral wall of the ischioanal fossa. The vessel crosses the ischioanal fossa, traverses the EAS to reach the submucosa of the anal canal and ascends in that plane. Its main significance is to supply the sphincter complex[31]. The venous drainage of the rectum is partly hepatic and partly systemic: through the inferior mesenteric vein to the portal vein or through middle and inferior hemorrhoidal veins that drain into the iliac vein then the inferior vena cava. Information on the middle rectal vein is sparse but its rate of appearance is similar to that of the artery and drains into the internal iliac vein[26].

The lymphatic drainage of the rectum follows the vascular supply. Drainage occurs to mesorectal (perirectal) lymph nodes (LN) then upward along the SHA toward the mesenteric LN along the IMA to lateral aortic and para-aortocaval LN[36,37]. The mesenteric LN stations include central intermediate LN (from origin of last sigmoid artery to the origin of the left colic artery) and central LN (from the left colic artery to origin of IMA). Drainage into paracolic LN is unusual. The lower rectum however has a cloacal origin and its lymphatic channels are part of the pedicles draining to lateral LN[38]. From the middle and lower rectum lymphatic drainage is mainly up wards along SHA and lateral to pelvic LN; downward spread is uncommon. Lateral drainage occurs to intermediate lateral LN (LN along the MHA outside fascia propria) and lateral main LN (along IIA and obturator artery) to para-aortic LN[36]. The number of LN found in the mesorectum ranges from 14-28 depending on the method of preparation of specimens[39,40]. The majority of the mesorectal LN are located posteriorly with few on each side. There are relatively few LN in the mesorectum of the lower rectum.

Clinical relevance

At presentation, about 70%-80% of rectal cancers are advanced either due to direct extension or lymphatic invasion. The mesorectum and outermost perirectal fascia act as barrier to the spread of the cancer and constitute the surgical "circumferential margin". Rectal cancer can spread outside the rectal wall in a continuous fashion or as discontinuous tumor extensions or deposits into the mesorectum up to 5 cm distal to the tumor margin[30,41-46]. Discrete nodules found in the extramural adipose tissue may represent LN replaced by tumor. In the absence of residual nodal tissue, nodules > 3 mm are classified as pN disease and ≤ 3 mm are classified in the pT3 category as discontinuous extramural tumor[47]. Involvement of circumferential margin by tumor is the main cause of local recurrence after rectal cancer surgery[46,48]. Circumferential margin is the nonperitonealized surface of the rectal specimen created by mesorectal dissection at surgery. Circumferential margin is considered positive if the distance between the deepest extent of the tumor and closest surgical clearance around the tumor, *i.e.*, circumferential resection margin (CRM), is 0 to 1 mm. CRM is an independent predictor of outcome in patients with rectal cancer[49-51]. When CRM is < 1 mm, local recurrence rate is 22% and when > 1 mm, the rate drops to 5%. Furthermore, CRM < 1mm is predictive of an increased risk of distant metastases (37% *vs* 15% for those with CRM > 1 mm) and shorter survival (70% *vs* 90% at 2 years for those with CRM > 1 mm). However, other investigators have considered 2 mm as the cutoff point. Nagtegaal *et al*[52] reported that the local recurrence was 16% for CRM < 2 mm *vs* 6% for patients with radial margins > 2 mm. Although the ideal CRM has not been universally accepted, resection with as wide of a CRM margin as possible must be accomplished. Circumferential margin for distal tumors is problematic since the mesorectum encases the rectum as a thick cushion mainly posteriorly and laterally proximally and inferiorly it thins out and tapers down to the anorectal junction making it impossible to obtain a 2 cm cuff of marginal tissue circumferentially. Lymph node involvement is the most important prognostic factor and a major determining factor whether a patient is candidate for adjuvant therapy. The overall survival is determined by number of LN involved. Violation of the perirectal fascia and transmesorectal dissection is associated with high local recurrence rate[24]. Local recurrence after rectal cancer surgery is associated with incomplete excision of circumferential margin, presence of isolated deposits in the mesorectum and tumor in regional LN and incomplete LN clearance[43,53,54]. To eradicate the primary rectal tumor and control regional disease, the rectum, first area of LN drainage (mesorectal LN) and surrounding tissue must be completely excised while maintaining an intact fascial envelope around the rectum and protecting and preserving surrounding structures, including the ureters, gonado iliac vessels, sacral venous plexus and pelvic autonomic nerves. To achieve such a radical resection, thorough knowledge of the pelvic structures and fascial planes is paramount.

Total mesorectal excision (TME), originally described by Abel[55] in 1931 and later adopted by other surgeon, implies removal of the entire mesorectum including portion distal to the tumor within its enveloping fascia as an intact unit[27,30,45,53,56,57]. TME is performed in conjunction with low anterior resection (LAR), abdominoperineal resection (APR), extralevator APR (ELAPR), and extraregional dissection (extended lymphadenectomy; lateral clearance). For mid- to low-rectal cancer, LAR with TME has been demonstrated to minimize locoregional recurrences[30,56-61]. For upper rectal cancer, or tumors > 10 cm from the anal verge, where a distal margin of 5 cm can be achieved, tumor specific mesorectal excision (TSMRE), *i.e.*, dividing the rectum and the mesorectum at the same level, is sufficient and is associated with results similar to that achieved with TME[53,62-64]. With, APR, the operative plane follows the mesorectum to the muscular tube of the rectal wall stopping at the puborectalis sling. The anus is removed by perineal approach and dissection is performed outside the edge of the EAS and leaving the ischioanal fat. With ELAPR, abdominal dissection stops at the rectosacral ligament and the anus, coccyx and most of the levator muscle are removed by perineal approach[19]. Lateral LN dissection may be performed with TME as part of an extraregional dissection (lateral clearance) for lower rectal cancer but the reported outcome is no different than that with TME[40,57,65]. Whether TME or TSMRE is performed, the technique of the excision is key: precise, sharp dissection is performed under vision outside the fascia propria of the rectum in the plane between the fascia propria and parietal pelvic fascia, *i.e.*, extrafascial dissection so as to remove the rectum with the enveloping fascia, as an intact package, without violating the fascial envelop of the rectum[16,27,30,45,58-60]. Sharp dissection facilitates identification and preservation of the autonomic nerves, allows adequate hemostasis and avoids tearing of the fascial envelope around the mesorectum. The inferior mesenteric vessels are divided and retracted with the rectosigmoid junction anteriorly, and extrafascial dissection is commenced.

Identification and preservation of the hypogastric nerves is discussed later. Dissection is performed between the fascia propria of the rectum and the presacral fascia posteriorly in the retrorectal space that contains loose areolar tissue and is devoid of vessels and nerves and pelvic wall laterally. Sharp dissection is performed under vision down to the rectosacral ligament posteriorly and lateral rectal ligaments laterally. The rectosacral ligament is divided so as to gain access and mobilize the last 2-3 cm of the rectum and the anorectal junction[21]. However with ELAPR, dissection stops at the rectosacral ligament. The mesorectal fascia is not detached from the parietal pelvic fascia and the levator muscle is not separated from the sacrococcygeal junction[19]. The sacrococcygeal junction is disconnected through the perineal phase to detach the coccyx that is the insertion of the midline raphe of the levator muscle. The parietal pelvic fascia is divided in the midline through the disconnected sacrococcygeal junction and the levator is divided laterally at both sides[19]. The anterior plane of dissection to separate the rectum from the prostate gland and vagina is controversial and is discussed later. However, dissection is performed inside the pelvic autonomic nerves down to the top of the anorectal junction where the rectum has little mesorectal fat and appears as a bare tube[25,31,32]. Laterally the lateral rectal ligaments are divided (detailed discussion to follow). Damage to the accessory branches rather than the main of the MHA may occur MHA during division of the lateral ligaments. The point of insertion of the MHA into the rectum is 5-6 cm from the anus. Damage to the main MHA occurs during dissection of the rectum anteriorly and anterolaterally on the pelvic floor, when it is being dissected off the seminal vesicle and prostate gland or vagina (vide infra). With extrafascial mesorectal excision, regional LN's (mesorectal LN) are removed. In surgical terms, the lymphatic spread of cancer occurs to perirectal (mesorectal LN) and upwards to intermediate central and central LN along the SHA and IMA. Down ward spread is uncommon. Lateral spread to lateral pelvic LN is more clinically important in tumors with lower margin below 5 cm from the dendate line and the incidence becomes significantly higher with lower margin below 3 cm above the dendate line[14,36,40]. Superior LN metastasis occurs in more than 30%-40% of rectal cancer patients and has great clinical significance[66]. Lateral spread from the lower rectum to the iliac LN occurs in about 15% of cases[14]. Lateral spread occurs to LN's along the MHA that lie outside fascia propria. With extended resection, *i.e.*, mesorectal excision with extraregional lymphadenectomy, lateral pelvic and or lumboaortic LN are removed. The number of LN removed with extrafascial mesorectal excision depends on level of the tumor. Canessa *et al*[39] in a study in formalin-fixed cadavers noted that the mean number of LN was 8.4 per specimen. The LN ranged in size from 2 to 10 mm. Most of the LN's (71.4%) were found around the branches of the SHA proximal to the peritoneal reflection and 28.6% were found distal to the peritoneal reflection. Topor *et al*[67] using LN clearing solution identified 25 LN per patient (average 14/mesorectum and about 5 for each pelvic side wall). The majority of LN's (> 80%) were small ($\leqslant$ 3 mm) and majority (56%) located posteriorly and most (92%) located within the mesentery of the proximal two thirds of the posterior mesorectum. The lower third of the rectum contained the fewest nodes (8% of LN) and most of LN's on the sidewall were located in the area of the middle rectum. It is shown that 12-15 LN must be examined to accurately determine node negativity and any less limits the predictive value of the pathologic examination[68,69]. The role of extended resections is controversial since randomized studies on survival benefits from the procedure are still missing. Opponents of lateral pelvic lymphadenectomy question the benefit of the procedure since only small percentage of patients have lateral LN involvement. The operative time with extended resections is prolonged and morbidity is high. Furthermore, their presence is indicative of systemic disease and hence patient's prognosis is poor. In addition some studies have shown lateral pelvic lymphadenectomy is not necessary in terms of curability for patients with advanced lower rectal cancer who undergo preoperative radiotherapy[70]. Several other studies reported the outcome with TME to be no different from the data on extended lymphadenectomy. Hence many surgeons in the Western World, Europe, to some extent in Japan favored the mesorectal excision only. The number of regional LN removed varies with location of the tumor and surgical technique.

LATERAL RECTAL LIGAMENTS

Considerable anatomical, surgical and physiological importance has been attached to the lateral ligaments of the rectum. Anatomists consider the ligaments as fascial bridge that act as a pathway for nerve fibers, small vessels and lymphatics from and to the rectum[28,50]. Surgeons recognize the ligaments as extraperitoneal thick bundle of dense connective tissue that provide pathway to lymphatic channels and contribute to the support of the rectum and in which the MHA and plexuses are embedded[71,72]. Proper handling of the ligaments during surgery has an important bearing on colonic, anorectal, sexual and urinary function as well as the prevention of local recurrence of the cancer[56,61,73-75]. To gain access to the depths of the lateral pelvis, full mobilization of the mid-lower rectum requires identification of the lateral rectal ligaments that are then clamped, divided and ligated to avoid intra- and post-operative hemorrhage since the MHA are large and do not respond to electro cautery[61]. Despite this clear-cut description and straightforward handling of the ligaments, there are many variations and contradictory accounts reported in the literature as to the nature, anatomy, and contents of the lateral rectal ligaments.

Surgical anatomy

Thomas Jonnesco[29] (1901) was the first to describe the lateral rectal ligaments as a continuation of the parietal fascia predominantly surrounding the origin of MHA from the IIA. Miles[76] (1910) in describing his technique with the APR stated that the dissection is carried downward on either side of the rectum until "the lateral ligaments can be realized as firm vertical bands of fascia requiring division with scissors". Goligher *et al*[61] (1984) described the ligaments, as seen from above, as having a triangular shape with the base on the pelvic sidewall and the apex joining the side of the rectum. Hojo[77] (1986) considered the ligaments as rectal structures that should be removed completely. Heald in original and subsequent articles (1980s)[30,45] and Reynolds *et al*[78] did not mention the lateral ligaments in their description of TME. Enker[75] (1992) recognized the ligament as an important landmark during autonomic nerve sparing sidewall dissection for rectal cancer. Takahashi *et al*[14] described the ligament as a bundle of dense connective tissue in the pararectal space with variable thickness and length that extends from the peripheral part of the IIA to the sidewall of the midrectum between the peritoneum and levator muscle. The hypogastric nerve fibers reach the center of the ligament where they unite with the PSN as they emerge from the sacral roots and form the inferior hypogastric nerve plexus inside the ligament[14]. Thus the ligament is divided into a lateral part that contains the MHA and inferior vesicle arteries and the medial part that holds nerve fibers to the rectum together with branches of MHA. In addition to branches of IIA and autonomic nerves, the lateral ligament provides a route for lymph vessels that penetrate the inferior hypogastric plexus and reach LN around the origin of the MHA.

Jones *et al*[34] in a study performed on cadavers embalmed in formalin found very insubstantial connective tissue strands and at times no definite connective tissue structure crossing from the pelvic sidewall to the rectum. The strands of fibrous tissue were inconsistent in direction, variable in height above the pelvic floor and often absent all together or present unilaterally. The MHA was present in 50% of pelves mostly as a unilateral structure, was closer to the pelvic floor and crossed the mesorectum independent of any structure. The branching PSN arose posterior to the origin of the MHA, ran in an anteromedial direction and reached the rectum at a similar height above the pelvic floor as the MHA. Boxall *et al*[31] described similar findings during anterior resections and found only accessory branches of the MHA crossing to the rectum in condensations of fascia in 25% of cases. Nano *et al*[33] in a study on fresh cadavers and embalmed pelves viewed the lateral ligaments as extensions of the lateral aspect of the mesorectum as approximately trapezoid structures with their apex towards the rectum. The ligaments ran caudally and distally and anchored to the endopelvic fascia. The ligaments contained fatty tissue in communication with mesorectal fat but did not contain any significant vascular structures. When present, in some cases unilaterally, the MHA crossed together with the nervi recti that arose from the inferior hypogastric plexus transverse almost perpendicular to the inferior aspect of the ligament at its distal end before entering the anteromedial aspect of the rectal wall. The urogenital bundle ran just above the lateral ligament at its insertion of the endopelvic fascia. Sato *et al*[26] visualized the ligaments in human as composed of three components, the MHA, middle rectal vein and the pelvic plexus. The most constant component was the PSN as the middle rectal vessels were often absent, identified in 22% of cases, and when present occurred unilaterally. When present the artery was long and tortuous and pierced the pelvic plexus. The MHA divided the ligament into medial and lateral segments. The artery entered the rectum mid-way between the superior and inferior branches of the pelvic plexus. The PSN arose somewhere posterior and inferior to the MHA. The lateral segment consists of two sheaths one surrounding the MHA and one around the PSN. The medial segment share a common sheath with the nerves and follow the same course as that of the rectal branches of the pelvic plexus. Pak-art *et al*[35] during sharp dissection on "soft cadavers" (cadavers freshly embalmed with CU-formula I solution, a preservative that renders muscles soft) recognized the lateral ligaments as white, opaque bands of connective tissue distinct from surrounding areolar tissue traversing the space between the posterolateral aspect of the rectum and mesorectum and the lateral aspect of the anterior surface of the third and fourth sacral vertebrae. These ligaments were closer to the coccyx than the promontory of the sacrum. Components of the ligaments were loose connective tissue containing multiple small nerves. Small arterioles and venules were present in the ligament in 11% of cases. Muntean[22] described the rectal stalks as the paraproctium that arise from the pelvic fascia and run medially and dorsally to reach the anterolateral wall of the rectal wall at 10 and 2 o'clock. The paraproctium houses the rectal nerves and middle rectal vessels when present.

Clinical relevance

The lateral rectal ligaments vary from insubstantial connective tissue strands to no definite connective tissue structure crossing from the pelvic sidewall to the rectum. The incidence of the vessels occupying the ligament varies from 22% to 100% depending on the caliber of the vessel present and exact relationship of the vessels to the ligament. The main MHA does not traverse the lateral ligament but rather send minor branches through them, unilateral or bilateral in only 25% of cases. Hence the ligaments can be divided with diathermy. The nervi erigentes lie in and under the endopelvic fascia and are close to the lateral margin of the ligament and together with the MHA do not run below them. The ligaments contain mesorectal fat and must be divided close to the pelvic wall to ensure optimal oncologic clearance. Leaving behind remnants of the ligaments implies inadequate adequate lateral clearance of the mesorectum[45]. Traction on the rectum may tent the endopelvic fascia with its enclosed nerves and puts the nerve at jeopardy during division of the ligament[22].

DENONVILLIERS' FASCIA

Separating the rectum from the anterior urogenital structures is a layer of tissue that is an important anatomical structure to the colorectal and urology surgeons for oncologic and functional reasons, particularly in males. Denonvilliers[79] was the first to describe in 1836 the "prostatoperitoneal membranous layer" as a thin layer of tissue that separates the rectum from the urinary bladder, seminal vesicles and prostate gland in men. A similar structure consisting of essentially the same tissues was found in female pelves separating the rectum from the vagina often referred to as the "rectovaginal septum"[80]. Denonvilliers' fascia and the rectovaginal septum are also referred to as the "rectogenital septum". There is controversy as to origin, morphology, function and anatomical relationship to the fascia propria and urogenital structures and whether it can be identified during surgery and the precise plan of anterior rectal dissection for rectal cancer.

Surgical anatomy

Earlier studies have suggested that the septum is formed either as a result of incomplete partition between the rectum and urogenital organs or represents peritoneal fusion or condensation of loose areolar tissue after peritoneal fusion[80-82]. Aigner *et al*[83] on the other hand noted that local condensation of collagenous fibers is present between the rectum and urogenital organs from the beginning of fetal development and subsequent increase in dense collagen fibers and longitudinal smooth muscle cells produced the anatomical partition.

Kourambas *et al*[20] found in autopsies of adult males that Denonvilliers' fascia was easily seen as a sheet of fibrous tissue lying between the prostate and the rectum that had no defined layers or lateral edges. The fascia widened laterally and became continuous with the perirectal fascia posteriorly and the lateral pelvic fascia between the levator ani and prostate anteriorly. Stelzner *et al*[16] noted in human cadaver pelvises thin connective tissue continuations spread out medially from the parietal pelvic fascia to interweave with lateral extensions of the Denonvilliers' fascia that separates the rectum from the vagina and prostate capsule. The fascia splits into a number of laminae laterally[16,19-21]. Prominent nerves are seen intermingled with the lateral aspects of Denonvilliers' fascia and its fascial continuations and extended medially almost to the midline. Others identified Denonvilliers' fascia as it ran almost vertically between the peritoneal reflection of the rectovesical pouch and the pelvic floor anterior and separate from fascia propria of the extraperitoneal rectum[18,27,84]. The septum forms an anatomical incomplete partition between the middle and posterior compartments in the female and the anterior and posterior compartments in the male that is completed by the perineal body distally[83]. Immediately anterior to the lateral borders of the fascia, the parasympathetic cavernous nerves run to supply the corpora and govern erectile function and are in jeopardy during deep anterior dissection of the rectum and are jeopardy[85].

Histologically, the rectogenital septum is predominantly made of connective tissue and contains smooth muscle fibers and sensory neurons[18,20,27,79,80,83]. The connective tissue consists mainly of dense collagenous fibers and few course elastic fibers derived from mesenchymal condensation[27,80,83]. The origin of the smooth muscle bundles may be traced to the external longitudinal muscle sheath of the ventral wall of the rectum at the level of the middle transverse fold of the rectum (Kohlrausch's valve) where the muscle layer appears thicker[83]. Similar muscle fibers are also noted within the anal sphincter musculature[83]. The smooth muscle fibers in the ventral rectal wall give origin to the longitudinal muscle of the anal canal and also bend caudally to traverse the rectogenital septum terminating in the perineal body that is a dense connective tissue that separates the urogenital hiatus from the anal hiatus. The longitudinal smooth muscle fibers are accompanied by small nerve bundles attached to the connective tissue of the perineal body. Neurovascular bundles coming from the autonomic inferior hypogastic plexus intermingle with the lateral margin of the septum and cross the midline between the septum and the rectum[83].

The precise function of the rectogenital septum is not clear but there is evidence to suggest an important role in urinary and fecal continence. In one study, intrinsic innervation was confirmed by the presence of parasympathetic nerves innervating the septum and sensory neurons present within the septum was demonstrated[83]. Neurovascular bundles coming from the autonomic inferior hypogastric plexus intermingled with the lateral margin of the septum and crossed the midline between the septum and the rectum. The rectogenital septum and its smooth muscle component share the same innervation as the longitudinal muscle layer of the rectum. The longitudinal muscle fibers in the septum terminate in the perineal body and act as anchors and when the muscle contracts it results foreshortening and opening of the anal canal[83].

Clinical relevance

To mobilize the midrectum, anterior dissection is performed to separate the anterior wall of the rectum from the urogenital structures. From the surgical point, there is controversy as to the appearance of the septum and whether it can be identified during surgery and plane of dissection during proctectomy.

Many surgeons believe the fascia is more closely applied to the prostate gland and seminal vesicles than the rectum[28,86]. Others describe the fascia as more closely adherent to the rectum than the prostate[87]. The operative appearance of the fascia varies considerably from a fragile translucent layer to a tough leathery dense membrane but overall it is more obvious and substantial than fascia propria which is a thin membrane enveloping the mesorectum[28,87]. It is often more prominent in the young and becomes less prominent with increasing age and women and becomes more prominent after preoperative radiotherapy or if there is transmural rectal inflammation as in Crohn's disease[37,65]. Heald *et al*[30] noted the fascia on the anterior surface of the mesorectum with a distinct plane separating this shiny fascia and the seminal vesicles. Thus during TME dissection takes the surgeon anterior to the fascia and thus resecting the fascia. Nano *et al*[88] suggested that the fascia "represented a plane of cleavage both with the rectum and between the two leaves that made it up" and that "the anterior leaf of the fascia is closely applied to the seminal vesicles." They believed dissection splits the fascia into two. Northover[89] and Bisset *et al*[27] on the other hand described dissection anterior to the fascia cranially then breaching it distally by dividing it transversely 1 cm below the base of the prostate in the male and opposite the vault of the vagina in the female to dissect posterior to it caudally. Others have maintained that excision of the fascia depends on location of the tumor in the rectum[59,64,84]. Lindsey *et al*[84] found Denonvilliers' fascia is left on the prostate and seminal vesicles during the usual anterior dissection in TME. For anterior and circumferential tumors in which the anterior margin is threatened, it is often taken with the specimen to gain maximal margin control[18]. In these cases the dissection is considered extramesorectal resulting in excision of the fascia[18,84]. With cancers sparing the anterior rectum, extramesorectal excision is not performed and in approximately half of anterior cancers dissection is extramesorectal and Denonvilliers' fascia is excised[18]. The risk of impotence is higher when tumors involve the anterior quadrant of the rectum because of the relationship of the cavernous nerves to Denonvilliers' fascia. In cases where the anterior circumferential margin is not threatened resection that does not jeopardize erectile dysfunction must be employed. To these cases the caudal portion of the ventral rectal wall including the septum must be left undissected[83]. Staying anterior to the septum behind the bladder and then posterior to it more caudally will prevent injury to the cavernous nerves and in consequence prevent erectile dysfunction[28,86]. Hence, in the male the peritoneum on the seminal vesicles is incised and dissection is carried anterior to Denonvilliers' fascia to the base of the prostate gland. In the female the peritoneum is incised in the pouch of Douglas. If the layers of the fascia are defined, the fascia propria and Denonvilliers' equivalent are excised with the specimen and if not defined stay close to posterior vagina. Dissection plane may be kept close to the rectum leaving the facia on the back of the vagina or prostate gland or between fascia propria and part of or all layers of Denonvilliers' fascia and equivalent fascia in the female[27,86].

The parasympathetic cavernous nerves run anteriorly, in close proximity to the lateral borders of the fascia to supply the corpora and govern erectile function[90]. These nerves are in jeopardy during deep anterior dissection of the rectum[85]. When disrupted during dissection of the distal aspect of ventral wall of the rectum during restorative proctectomy, the anchoring mechanism of the septum is interfered with and incontinence may result[90]. On the other hand when the caudal portion of the ventral rectal wall including the septum are left undisturbed during sphincter preserving procedure potency and continence are preserved[90].

PELVIC NERVES

Surgical anatomy

Parasympathetic innervation to the proximal colon down to the transverse colon runs *via* the vagus nerve and sympathetic innervation *via* postganglionic fibers from the paravertebral sympathetic chain. The left colon and rectum receive sympathetic innervation from the preaortic plexus and presaral nerves and retrograde parasympathetic innervation from neural efferents running through the lateral ligaments.

The sympathetic nerves arise from the thoracolumbar center T11-L2. Preganglionic fibers synapse in the pre-aortic plexus and postganglionic fibers follow the branches of the IMA and SHA to the left colon and upper rectum. The presacral nerves formed by fusion of aortic plexus and lumbar splanchnic nerves form the superior hypogastric plexus that gives rise to the right and left hypogastric nerves that innervate the lower rectum. The hypogastric nerves run between the presacral fascia and fascia propria and send nerves to the pelvic plexus (also termed inferior hypogastric plexus)[65]. The retroperitoneal fascia covers the lumbar sympathetic nerves and superior hypogastric plexus and the plexus is situated directly in the visceral fascia above the bifurcation of the aorta[65]. The hypogastric nerves separate from the plexus and descend caudad and laterally passing for a short distance through the visceral endopelvic fascia. The right and left hypogastric nerves run distally about 1 cm lateral to the midline and 1-2 cm medial to the ureters[27]. Thereafter the hypogastric nerve fibers are situated close to the visceral endopelvic fascia[14].

The parasympathetic nerves are formed largely by visceral efferent preganglionic fibers that arise from sacral nerves (mainly S3-S4, at times S2) and contain sensory nerves (PSN)[26,71]. The PSN are identified as two bundles on either side that emerge from the sacral roots, travel over the piriformis muscle covered by the endopelvic fascia[26,65]. The largest branch is S3 that runs caudal to the middle rectal artery and vein. The PSN pass laterally, forward and upwards and join the parietal pelvic fascia and the pelvic plexus within it very close to the anterolateral aspect of the lower rectum and the upper lateral wall of the vagina or posterolateral aspect of the prostate[16,65]. The inferior pelvic plexus is a complex network of sympathetic and parasympathetic nerves, located between the internal iliac vessels and the rectum on the pelvic sidewall amid the parietal pelvic fascia well outside the fascia propria of the rectum and is divides the MHA into a lateral and medial segments[16,26-28,91]. It is the center of autonomic innervation of the pelvic visceral. Branches from the inferior pelvic plexus diverge in fanlike pattern and innervate the urinary bladder, distal ureters, seminal vesicles, prostate, membranous urethra, corpora cavernosa, uterus and vagina, rectum and the perineal body[16,26,65,71]. The nerve to the rectum diverge directly from the plexus into the rectal wall (T-junctions) and the remaining nervous network form the neurovascular bundles[16]. The nerves to the rectum arise from the pelvic plexus as a 1 cm long band course towards the rectum accompanied by small vessels along fascial fibers (lateral ligaments) and reach the rectal wall 6 cm above the anus or similar height above pelvic floor as the MHA[25,34].

Clinical relevance

Damage to the pelvic nerves results in sexual and urinary dysfunction[92]. In conventional surgery for rectal cancer as well as TME as initially described and extraregional dissection (lateral clearance) performed by the Japanese in the 1970's and 1980's, the autonomic nerves are sacrificed to achieve radical surgery[30,83,92]. In the mid 80's and thereafter, autonomic nerve preservation (ANP) was adopted by the Japanese and European surgeons and applied by the Western surgeons to preserve urologic and sexual function while maintaining oncological principles[14,27,58,91-93]. Surgical procedures for treatment of rectal cancer have changed to TME, and TME and extraregional dissection (lateral clearance) with ANP. ANP may be total where major components of the pelvic nerves are identified and preserved or partial where one or more component is sacrificed unilaterally or bilaterally[65].

During TME, the superior hypogastric plexus and nerves, PSN and the pelvic plexus are encountered and adequate mobilization of the mesorectum can be achieved while preserving these nerves. The superior hypogastric plexus can be identified on the front of the aorta at the level of the aortic bifurcation[94]. The right and left hypogastric nerves are identified about 1 cm lateral to the midline and 1-2 cm medial to the ureters[27]. Thereafter the hypogastric nerve fibers are situated close to the visceral endopelvic fascia. Extrafascial dissection is performed along a plane medial to the hypogastric nerves that are followed laterally and caudally[27]. The ureters invested in the urogenital fascia pass over the iliac vessels normally at the bifurcation of the iliac vessels then run laterally always lateral to the hypogastric nerves on the pelvic wall under the peritoneum of the pararectal fossa[22,23]. In females, the ureter crosses dorsal to the ovary and underneath the broad ligament within 2 cm of the uterine vessels. In males, the vas deferens crosses ventral to the ureter as it courses from the midline prostate to join the gonadal vessels laterally near the internal inguinal ring. The lateral rectal ligaments are divided sharply and in the process the nerves to the rectum arising from the pelvic plexus (T-junction) are sharply transected thus separating the mesorectum from the pelvic autonomic nerves undamaged on the lateral pelvic wall. The inferior hypogastric plexus and pelvic nerves lie on the pelvic sidewalls amid the parietal pelvic fascia well outside the fascia propria of the rectum[27,28,91].

Preservation of the urinary bladder nerves requires identification of the vesicorectal interspace[65]. The vesicorectal interspace emerges when the anterior rectal wall is mobilized. Branch to the urinary sphincter is found in a groove between the rectum and levator muscle beneath the levator fascia. From its origin in the inferior hypogastric plexus the pelvic nerve to the urinary bladder sphincter courses in a groove inferomedial to the rectum. At the level of prostatic apex it courses around the rectum en route to the urinary sphincter and there it susceptible to injury when the levator muscles are divided during APR. As the plans between the rectum and prostate is developed, if Denonvilliers' fascia is violated the continence nerve near the apex of the prostate can be injured.

CONCLUSION

Extrafascial dissection describes removal of the rectum, regional LN and mesorectum as a package with an intact envelope while protecting and preserving surrounding structures.

Sharp dissection is performed under vision in the plane between fascia propria of the rectum and parietal pelvic fascia posteriorly and pelvic wall laterally. The superior hypogastric plexus is identified on the front of the aorta at the level of the aortic bifurcation. The right and left hypogastric nerves are identified about 1 cm lateral to the midline and 1-2 cm medial to the ureters. Thereafter the hypogastric nerve fibers are situated close to the visceral endopelvic fascia. The ureters pass over the iliac vessels normally at the bifurcation of the iliac vessels then run laterally always lateral to the hypogastric nerves on the pelvic wall under the peritoneum of the pararectal fossa. In females, the ureter crosses dorsal to the ovary and underneath the broad ligament within 2 cm of the uterine vessels. In males, the vas deferens crosses ventral to the ureter as it courses from the midline prostate to join the gonadal vessels laterally near the internal inguinal ring. The recto-scaral ligament is divided to gain access and mobilize the last 2-3 cm of the rectum and the anorectal junction when an APR is performed or not divided when ELAPR is performed. The lateral rectal ligaments are divided close to the pelvic wall with diathermy close to the pelvic wall since the main MHA does not traverse the lateral ligament but rather sends minor branches through them. The nerves to the rectum arising from the pelvic plexus (T-junction) along the ligament are sharply transected in the process thus separating the mesorectum from the pelvic autonomic nerves undamaged on the lateral pelvic wall. The inferior hypogastric plexus and pelvic nerves lie on the pelvic sidewalls amid the parietal pelvic fascia well outside the fascia propria of the rectum. Denonvilliers' fascia is left anteriorly on the seminal vesicles and prostate gland or dissection is carried anterior to the fascia cranially then the fascia is breached distally by dividing it transversely 1 cm below the base of the prostate in the male and opposite the vault of the vagina in the female. However, for anterior and circumferential tumors in which the anterior margin is threatened, the fascia is taken (extrafascial dissection) with the specimen to gain maximal margin control. Extrafascial dissection is performed along a plane medial to the hypogastric nerves that are followed laterally and caudally.

Extrafascial dissection is a safe and oncologically sound radical resection associated with low locoregional recurrence and satisfactory urogenital and intestinal functional results. The treatment can be achieved only with thorough knowledge of the surgical anatomy and topographic relationship of the rectum to the surrounding structures and adherence to sound oncologic principles.

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