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Optimal surgical techniques for curative resection of the rectal cancer

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Abstract

The aim of rectal cancer surgery is to achieve a curative resection by completely removing the rectum involved with cancer surrounding the mesorectum, obtaining a safe adequate resection margin, and preserving important structures crucial for the patient's quality of life. Optimal dissection along the avascular embryological fusion line and among deep invisible structures is essential. Whereas a minimally invasive surgical approach allows for better visibility of deep pelvic structures compared with the open surgery period, the sequence of dissection and anatomical knowledge about pelvic fascia and relevant nerve structures are crucial for safe pelvic dissection in terms of oncologic and functional outcomes. In this review, we represent practical technical tips based on personal experience and previous studies to achieve the mentioned goals.

Keywords: Rectal cancer; Optimal surgical technique; Total mesorectal excision

1. Introduction

The most important practical aspect of optimal surgical treatment for rectal cancer is the complete removal of cancer without leaving any residual disease. In recent years, the total neoadjuvant treatment concept has been adopted treatment of advanced rectal cancer, and several clinical trials, such as RAPIDO and PREDIGE 23, have shown improved oncologic outcomes compared with conventional treatment methods. However, debates still exist.[1,2]

Surgical treatment, along with safe recovery, is the most important aspect of rectal cancer treatment. Colorectal surgeons have been trying to improve their techniques and have transferred them to minimally invasive surgical techniques. In this article, we aim to describe optimal surgical techniques based on personal experiences of more than 30 years working at Severance Hospital, Yonsei University College of Medicine.[3,4]

The surgical techniques proposed by R.J. Heald for reducing local recurrence and achieving R0 resection with nerve preservation have been widely accepted as the criterion standard in the surgical treatment of rectal cancer, commonly known as total mesorectal excision (TME).[5] R.J. Heald commented in his book that he initially decided to use the term *mesorectum* to include all the adipose tissue that contained the vascular and lymphatic structures involved in the spread of rectal cancer. Although TME has become a well-known term globally, there has been some debate regarding the use of the term *mesorectum*. Critics argue that it is not anatomically proper term, as the term *mesentery* typically refers to a structure consisting of a double layer of peritoneum facilitating vascular access to intraperitoneal organs.[6,7] Nonetheless, TME has become a symbol of curative surgery for rectal cancer and has been used for nearly 40 years. In this text, we have chosen to use the term *mesorectum* for consistency and clarity.

One critical issue in surgical treatment for rectal cancer is the risk of unintended dissection along the wrong interfaces, which could lead to damage to the pelvic autonomic nerves or problematic bleeding. Therefore, it is essential to accurately identify the perirectal fascia and its corresponding interfaces and structures. Understanding the named anatomical structures in the narrow concave pelvic cavity and the complex system of perirectal fascia with respect to its multilayered architecture, corresponding interfaces, and fusion zones is critical.

Junior colorectal surgeons often encounter technical difficulties in achieving optimal anatomical pelvic dissection in the deep, narrow concave pelvic cavity. One of the most challenging aspects is anterior dissection, as the anterior part of the rectum below the peritoneum is difficult to expose and usually has a thin mesorectum compared with the lateral and posterior rectal wall. Another challenge is identifying the relationship between the tumor and the levator ani muscle. The course of the pelvic autonomic nerves should be identified in relation to the perirectal fascial envelope, although they cannot be directly visualized.

The identification of the mesorectal fascia and parietal pelvic fascia is crucial. The rectum is mobilized following this interface in a craniocaudal direction and from a medial to lateral direction. Posteriorly, the rectosacral fascia is the most frequent and important fusion line, which merges with the mesorectal fascia enveloping the mesorectum. Laterally, the outer lamella of the parietal pelvic fascia covers the pelvic plexus and is attached to the surrounding mesorectal fascia, where the middle rectal artery may be located. Anteriorly, it is important to identify Denonvilliers fascia (DVF) near the seminal vesicle or vaginal wall. The mesorectal fascia anteriorly envelops the thin mesorectum and is separated from the DVF. After the rectum has been circumferentially mobilized from the

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surrounding structures and dissected along the accurate interfaces, the pelvic floor is exposed, allowing assessment of the levator ani muscle and anorectal junction, among others.

In this review, we described basic pelvic dissection along the fascia interface with no bleeding, that is, along the embryological plane. In addition, technical tips and highlight pitfalls based on experiences were provided. We fully agree with Dr Stelzner's conclusion: the 2 lamellae of the parietal pelvic fascia and the fascial fusion zones are key structures of the perirectal anatomy, and recognition of the inner lamella of the parietal pelvic fascia is crucial for autonomic nerve preservation.[8] The patient's specimen photographs and surgical videos used in this study have obtained approval from the Institutional Review Board of Yongin Severance hospital (IRB number, 9-2022-0083).

2. Basic Anatomical Structure

The purpose of surgical treatment for rectal cancer is to achieve a curative resection with a safe recovery. Controlling local recurrence is particularly important, as it can cause intractable pain, bleeding, and local sepsis, which can significantly impact a patient's quality of life. Pelvic dissection is often performed in the deep, narrow pelvic cavity, which is surrounded by complex neuroanatomical structures.

One crucial structure in perirectal anatomy is the fascial fusion zone. Understanding perirectal fascia anatomy is crucial for autonomic nerve preservation, and it is essential to recognize the inner lamella of the parietal pelvic fascia, as well as deep pelvic fascia, such as DVF, the pelvic plexus, and the neurovascular bundle. The rectosacral fascia should also be kept in mind because accidental damage to this structure can result in rectal perforation or presacral venous bleeding.[9,10]

In this text, we described the important anatomical structures necessary for safe and effective oncologic and functional surgery for rectal cancer. The rectum and mesorectum are located in the curved, concave pelvic cavity, primarily within the retroperitoneal cavity. To ensure complete and safe surgery, it is crucial to obtain complete integrity of the distal mesorectum enveloped by the mesorectal fascia. However, this can be challenging because of the narrow and deep operating space and the proximity of fascia and neurovascular structures. Nevertheless, a thorough understanding of these anatomical structures, based on a 3-dimensional (3D) concept, can facilitate a safe and successful pelvic dissection while also preserving neural structures and obtaining a good TME specimen.

2.1. The shape of the mesorectum

It is critical to understand the shape and location of the mesorectum within the pelvic cavity, which is made up of bones and other structures. The rectum's mesentery is surrounded by the rectal proper fascia and makes contact with adjacent fascia, nerve, and vessel structures. To ensure that the mesorectum is fully separated from surrounding structures and detached from the underlying pelvic floor, the deep, narrow, and concave pelvic cavity must be carefully navigated. The mesorectum should not be coned down because it may contain metastatic lymph nodes or tumor deposits. Figure 1A illustrates the shape of the mesorectum in a narrow pelvic cavity, where performing a true pelvic dissection (indicated by the blue arrow) can present a significant challenge for achieving complete TME and preserving pelvic autonomic nerves.

The pelvic dissection sequence is critical for obtaining a complete TME specimen. By carefully dissecting and removing the mesorectal fascia and associated structures, including lymph nodes, the surgeon can ensure that the tumor is fully removed with a clear margin, and the risk of local recurrence is minimized. Figure 1B shows a complete TME specimen, depicting a complete mesorectum with intact rectal proper fascia.

2.2. The concept of circumferential resection margin

The Korean fast food "Gimbob" serves as a useful analogy to illustrate the importance of a complete TME specimen and the impact of preoperative therapy. Gimbob consists of rice and vegetables wrapped in seaweed and sliced. By examining a cross-section of Gimbob, one can observe how closely the inner contents are packed within the seaweed. This visual representation highlights the criticality of achieving complete tumor removal with a clear margin to prevent local recurrence (Fig. 2).

Just as mishandling the outer seaweed can cause the inner contents to spill out, incomplete TME can lead to the spread of cancer cells and recurrence. Preoperative chemoradiation therapy or total neoadjuvant therapy can be used to shrink the tumor's size, facilitating the attainment of a complete TME specimen and reducing the risk of incomplete TME. Consequently, the chances of achieving complete tumor removal are improved.

In summary, the Gimbob analogy effectively elucidates the significance of complete TME and emphasizes the role of preoperative therapy in diminishing the likelihood of local recurrence in rectal cancer surgery.

2.3. Pelvic fascia

The embryological fusion fascia plane must be followed during pelvic dissection for rectal cancer, which can be difficult because of the narrow and concave pelvic cavity. Traditionally, this type of dissection was performed by hand, making it difficult to avoid injuring adjacent organs and damaging the mesorectal fascia, which can result in tumor cell spillage. Surgeons can navigate this complex area with greater precision and safety by using laparoscopic or robotic surgery and a 3D anatomical concept. To ensure that the mesorectal fascia is preserved and tumor cells are contained, proper traction and counter traction are required at all stages of the procedure. Figure 3 shows the relationships between the fascia around the rectum, including the rectal proper fascia (which covers the mesorectum), the presacral fascia (which covers the sacrum), DVF (a dense membrane between the anterior rectum and seminal vesicle/prostate gland), and Waldeyer fascia (a dense connective tissue between the rectal proper fascia and presacral fascia at the S3 and S4 level).

2.4. Rectosacral fascia (Waldeyer fascia)

In the deep, concave, and narrow pelvic cavity, the presacral fascia covers the sacrum and presacral venous system and is fused to the mesorectal fascia. The rectosacral fascia, also known as Waldeyer fascia, is found at the S4 level and can vary in thickness (Fig. 4). It is critical to avoid tearing this fascia, as tearing it can cause damage to the presacral fascia and significant presacral venous bleeding. Manual dissection in this area during open surgery used to frequently result in severe bleeding, necessitating surgical packing and compression to stop.[9,10]

2.5. Denonvilliers fascia

The DVF (a white membrane located at the anterior part of the rectum) is encountered in males during pelvic dissection at the level of the seminal vesicle (Fig. 5). This structure serves as an important landmark and must be considered to ensure both oncologic and functional safety. The DVF is easily separated from the seminal vesicle, but it is more firmly attached to the prostate, which descends to the perineum.[11] Figure 5 also showed that 3D micro-computed tomography (CT) study with

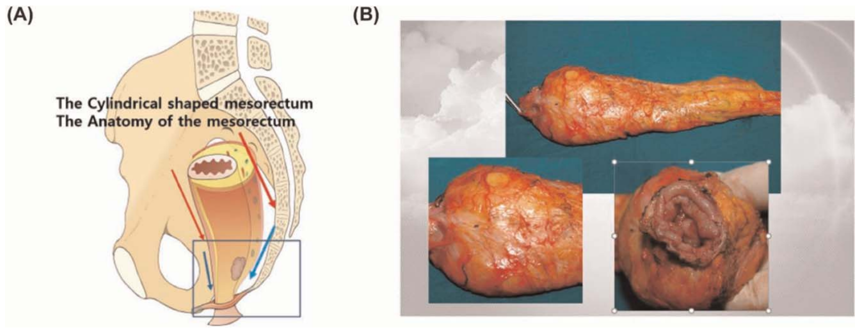

Figure 1. A, "The mesorectum was located in a deep, narrow, concave pelvic cavity. The blue arrow indicated a true, deep pelvic dissection." B, "The complete mesorectum showed an abundant intact mesorectum, although it was located in a deep, narrow pelvic cavity. It must not have been constricted." Reproduced from Kim et al. *Yonsei Med J*. Mar 2021;62 (3):187–199, with permission.[3]

cadaver depicted a course of DVF. Thus, unless the tumor is located anteriorly, it is critical to perform the anterior pelvic dissection posterior to the DVF. This approach will help prevent damage to the neurovascular bundle and genitourinary organ. The neurovascular bundle from the pelvic plexus runs along the tip of the seminal vesicle in the 10 o'clock and 2 o'clock directions and reaches the urogenital organ. Figure 6 shows that a histologic study revealed that the neurovascular bundle is located at the posterolateral side of the seminal vesicle and prostate gland, posterior to DVF.

2.6. Pelvic autonomic nerve system

The inferior hypogastric nerve plexus (sympathetic) and the pelvic splanchnic nerves are the autonomic nerves that innervate the pelvic viscera (parasympathetic). The superior hypogastric plexus descends along the sacral promontory and bifurcates into hypogastric nerves. It is located around the inferior mesenteric artery. These paired nerves enter the pelvis and run along the posterolateral wall. After removing the parietal pelvic fascia, the Y-shaped nerve structure composed of the hypogastric and pelvic splanchnic nerves can be observed on the lateral pelvic wall, originating from the second to fourth sacral spinal nerves (Fig. 7). The neurovascular bundle, which descends to the urogenital organ at the lateral corner of the seminal vesicle and prostate gland in the 10 o'clock and 2 o'clock direction, originates from the pelvic plexus. It is critical to understand the relationship between the fascia and surrounding nerve structures such as the pelvic plexus and neurovascular bundle during sharp pelvic dissection.

2.7. Lateral ligament at the lateral part of the rectum

First and foremost, it is important to understand the lateral part of the rectum. The relationship between the neurovascular bundle and the more lateral aspect, where the relationship between the mesorectal fascia and the pelvic plexus, as well as the middle rectal artery, should be understood, should be prioritized.

Surprisingly, meticulous dissection around this area is now possible thanks to the use of stable magnified operative fields provided by laparoscopic or robotic camera systems.

This area was previously known as the "dense fixing structure" or lateral ligament. However, because of the deep and narrow pelvis, the fused mesorectal fascia and pelvic plexus can be difficult to dissect. Excessive traction has been used in the past on this area, which can be avoided with the use of advanced technology and techniques.

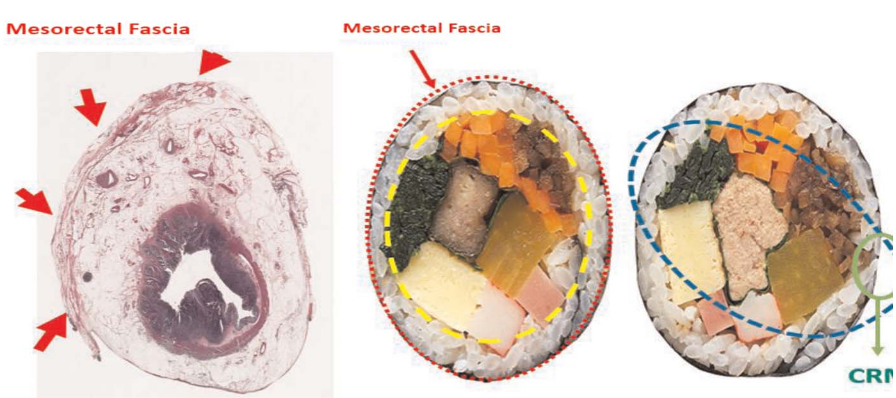

Figure 2. On the left side, the mesorectum was enveloped by collagenous tissue (rectal proper fascia). On the right side, Korean gimbob was shown with an outer layer of seaweed that matched the rectal proper fascia. If the inner food content encroached on the outer seaweed capsule, it would have threatened the circumferential resection margin.

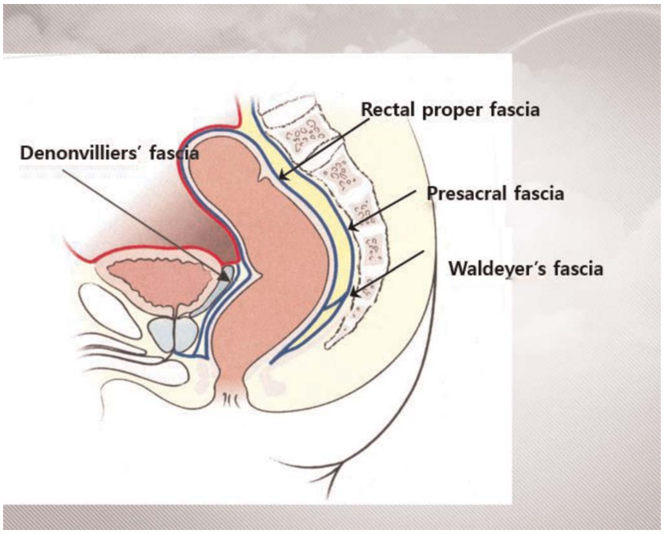

Figure 3. This schematic sagittal view of the pelvis illustrated the named pelvic fascia. The rectal proper fascia covered the mesorectum. Below the peritoneal reflection, the anterior DVF, a dense membrane between the rectum and seminal vesicle, was shown. Posteriorly, the rectosacral fascia (Waldeyer fascia), a dense connective tissue between the posterior part of the rectal proper fascia and the presacral fascia at the S3 and S4 level, was present. The presacral fascia, which covers the sacral bone periosteum, was also present. Reproduced from Lee and Kim. *Ann Coloproctol*. Apr 2018;34 (2):59–71, with permission.[7]

2.8. Middle rectal artery

When performing posterior or posterolateral rectum dissection, it is crucial to prevent excessive traction, which could damage the middle rectal artery and pelvic plexus. The prevalence of the middle rectal artery ranges from 12% to 97%.[12] A recent study by Heinze et al[13] reported a 71.4% incidence based on the dissection of 23 cadavers. The diameter of the middle rectal artery ranged from 0.5 mm to 3.5 mm, with bilateral presence found in 21.4% of cases. Given the risks of injury to this vessel and the pelvic plexus, it is critical to exercise caution and consider bleeding control strategies during dissection.[14] Figure 8 shows the middle rectal artery during robotic deep anterolateral pelvic dissection, with clear visualization of DVF, the pelvic plexus, and the direction of the neurovascular bundle.

2.9. Levator ani and anal sphincter complex

To achieve complete rectal mobilization, a thorough understanding of pelvic floor anatomy is required. Awareness of funnel-shaped pelvic floor is essential for achieving a complete rectal mobilization (Fig. 9A). The levator ani muscles, which include the pubococcygeus, iliococcygeus, and puborectalis muscles, make up the pelvic floor. A cadaveric view after the removal of the sacrum can show clear shape of pelvic floor (Fig. 9B). These muscles form a funnel-shaped structure, which is important to remember during dissection. The puborectalis muscle has a U shape and can be seen clearly during deep pelvic dissection. This muscle is essential for preserving the anorectal angle, which is necessary for fecal continence.[10]

3. Practical Surgical Technical Tips and Pitfalls

3.1. Colon mobilization

There remains a debate regarding whether high ligation of the inferior mesenteric artery or low ligation (leaving the left colic artery) is better for oncologic outcomes in cases of splenic flexure colon mobilization.[15] To reduce the tension of the mesentery, high ligation should be performed, the marginal artery along the descending colon should be carefully checked, and the inferior mesenteric vein should also be ligated. The arc of Riolan should be inspected very carefully. Indocyanine green fluororescence study can be helpful in assessing the vascular perfusion of the descending colon.[16,17]

An incision was made on the lateral peritoneal reflection and the superior rectal artery while applying traction to the rectosigmoid colon. This incision was made to identify the mesosigmoid interface,

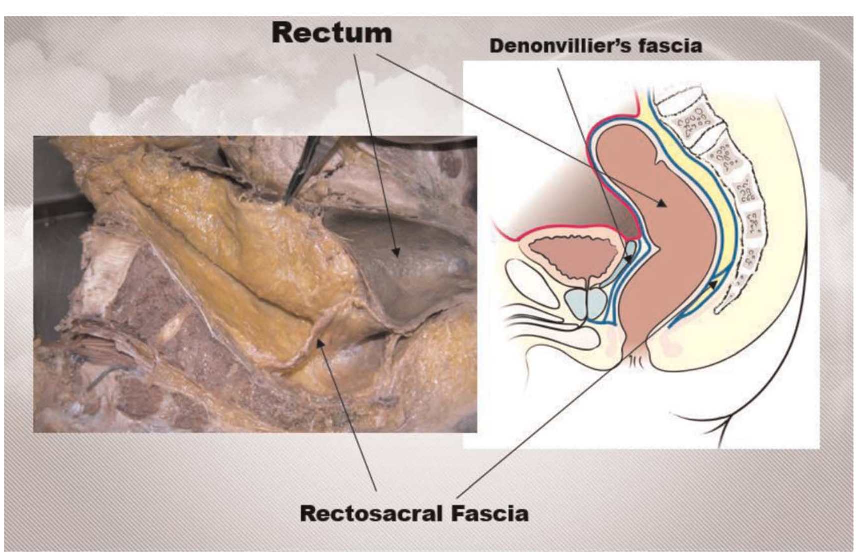

Figure 4. The cadaveric hemipelvis specimen showed a rectosacral fascia between the mesorectal fascia and presacral fascia at the S4 level (indicated by the black colored arrow).

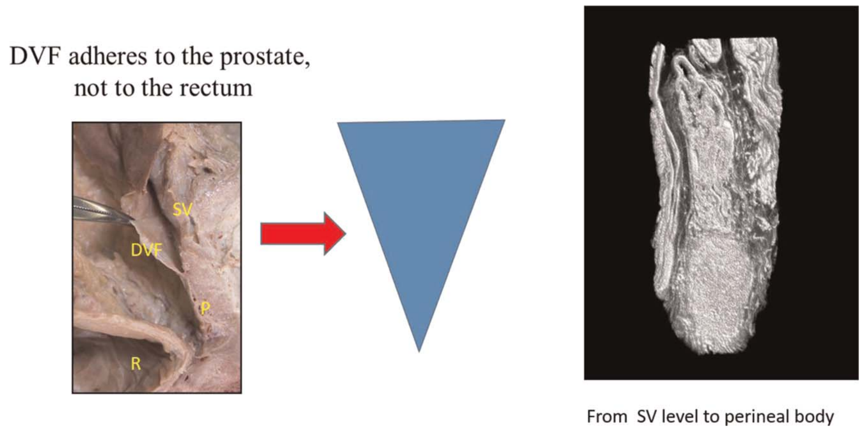

Figure 5. The apron-shaped DVF was located between the seminal vesicle, prostate, and rectum. It appeared to be more densely attached to the prostate gland and descended to the perineal body on the left side. Three-dimensional micro-CT revealed the trajectory of DVF on the right side.

from where the pedicle of the superior rectal artery should be followed. The parietal fascia covering the prehypogastric nerves and both common iliac arteries was then exposed. The pedicle of the mesosigmoid colon containing the superior rectal artery, enveloped with the mesorectal fascia, was completely dissected from the structure. With continuous traction of the rectosigmoid junction, the retrorectal space was entered. Sometimes, a sharp dissection along the mesorectal fascia enveloping the vascular pedicle may be necessary, but this can result in difficult-to-control bleeding in the case of a Bovie injury to the vascular pedicle. Therefore, proper mobilization and traction of the colon are important. The sequence of pelvic dissection plays a vital role in ensuring a safe surgery, and we recommend using the step-by-step approach referred to as the Rainbow method.[3,18]

3.2. Posterior dissection

Dissection was performed along the thin lamella of the parietal fascia covering the hypogastric nerve plexus in the retrorectal space. The hypogastric nerves, which are a continuation of the superior hypogastric plexus arising from T10 to L3 as part of the preaortic sympathetic nerve trunk, were carefully preserved. The posterior dissection was performed along the rectal proper fascia enveloping the mesorectum, leaving the hypogastric nerve intact along the pelvic sidewall. The

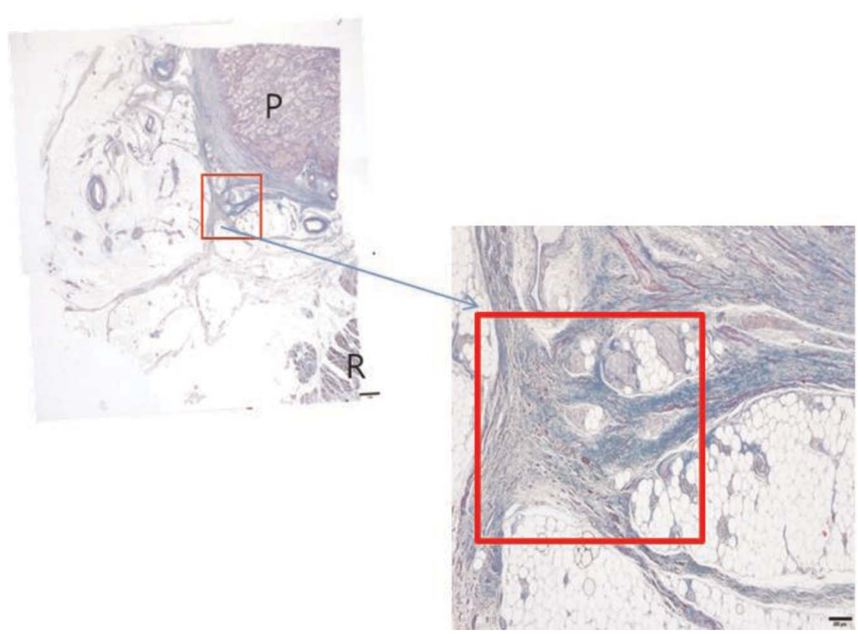

Figure 6. The histological study of the cadaveric specimen revealed that the neurovascular bundle to the genital organ was situated on the posterolateral side of the prostate gland, posterior to the DVF. Each neurovascular bundle was found at the so-called 10 o'clock and 2 o'clock directions. The neurovascular bundle is highlighted with a red box.

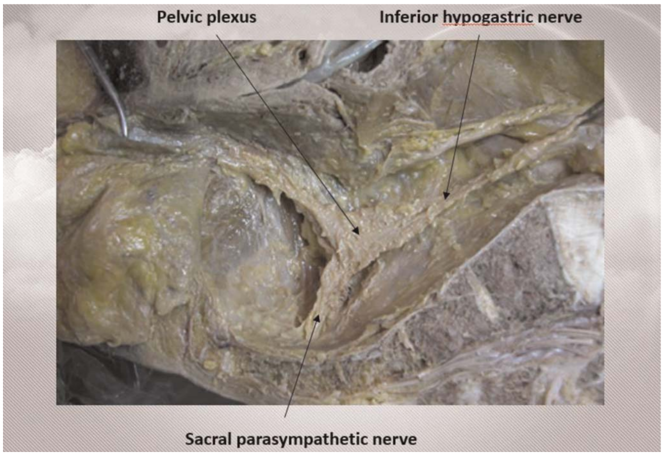

Figure 7. After removing the parietal pelvic fascia, the cadaveric hemipelvis showed Y-shaped nerve structures. The inferior hypogastric nerve descended along the pelvic sidewall and joined with the sacral splanchnic nerve to form the pelvic plexus. From this plexus, the neurovascular bundle extended to the genitalia. Reproduced from Lee and Kim. *Ann Coloproctol*. Apr 2018;34 (2):59–71, with permission.[7]

visceral pelvic fascia is a fibrous envelope that surrounds the mesorectum. It is also known as the fascia propria of the rectum.

3.3. Anterior dissection

After anterior peritoneal reflection incision, it is critical to identify the seminal vesicle in men and the vaginal wall in women, as these structures serve as important landmarks for proper anterior dissection. Failure to recognize these landmarks may result in bleeding or organ damage. Unless the tumor invades the seminal vesicle or vagina directly, anterior dissection should be performed posterior to the DVF. This method is recommended to preserve the neurovascular bundle, which is essential for sexual function.

3.4. Deep posterior dissection

Because of the concave cavity along the curved sacrum and the limitations of the pelvic cavity boundary imposed by the ischial tuberosity and iliac wing, performing a complete TME becomes difficult at this point. Furthermore, there is very little space at the level of the anorectal ring for a good surgical view. Despite the difficulty, surgical space must be created and an attempt should be made to induce a "coning down" and breach the mesorectum. A sharp incision is usually used to identify and divide the rectosacral fascia, revealing the presacral venous plexus covered by the parietal pelvic fascia. To ensure a safe dissection, maintain constant and adequate dissection and avoid blunt dissection. There is a risk of presacral fascia avulsion and presacral vein bleeding if the rectosacral fascia is not identified and sharply divided. A complete and safe deep posterior dissection allows for pelvic dissection in another direction. According to one study, it occurred in 15% of cases at the S2 level, 38% of cases at the S3 level, and 46% of cases at the S4 level.[19]

Deep posterior dissection is a challenging step, especially at the level of the anorectal ring where limited space can make it difficult to obtain an optimal TME while preserving the nerves. Careful dissection and proper use of instruments can help avoid potential surgical pitfalls and ensure a successful TME procedure.

3.5. Deep anterolateral dissection

The sequence of pelvic dissection in a deep narrow pelvic cavity is important for obtaining a complete TME specimen. Figure 10A shows an optimal dissection plane along the plane between the named pelvic fascia. Several important landmark structures, such as the DVF, prostate, vagina, neurovascular bundles, and pelvic plexus, must be remembered during this area of dissection. Deep anterolateral pelvic dissection can be particularly difficult in males with narrow pelvises, necessitating knowledge of these structures and technical tips. Deep anterolateral dissection begins with the DVF, and after dissecting below it, an avascular plane can be created with proper traction and gentle countertraction between the mesorectal fascia and the neurovascular bundle. The "Gate approach" allows entry into the anterolateral portion of the lower rectum by countertraction of the seminal vesicle and the neurovascular bundle at 2 o'clock.[10,11,20] Figure 10B depicts a schematic drawing of the Gate approach for easy understanding.

An incomplete TME may result from a lack of understanding of these structures, resulting in nerve damage and suboptimal outcomes. During this stage of the dissection, it is critical to completely separate the mesorectal fascia from the underlying pelvic floor. This step takes a different amount of time depending on the patient's unique characteristics and sex. The pelvic plexus can be easily separated from the mesorectal fascia at the lateral attachment site. The middle rectal artery may occasionally appear and can be controlled with monopolar or bipolar diathermy cauterization.

The Gate technique is an effective way to expose the middle rectal artery while keeping the pelvic plexus intact. The anterolateral dissection of TME includes this approach, which begins behind the distal visceral fascia on the lateral side and detaches from the mesorectal fascia. The dissection continues to the deep pelvic floor, forming a distinct "gate" between the mesorectal fascia and the pelvic floor. In addition to the deep posterior dissection, moving forward in this surgical plane will leave the lateral attachment and upper connective tissue layer hanging like a bridge between the parietal and mesorectal fascias, allowing the dissection to continue with the ligation of the middle rectal artery, if present, while preserving the pelvic plexus with the parietal wall (Fig. 10C).

3.6. Deep posterolateral dissection

After dividing the ventral layer of the anococcygeal ligament, the pelvic floor becomes visible. An anatomical study revealed that the anococcygeal ligament is consisted of 2 layers: the dorsal layer and ventral layer of the levator ani muscle.[21] In the case of proceeding with abdominoperineal dissection, dividing the dorsal layer of the anococcygeal ligament exposes the posterior aspect of the pelvic floor.

During dissection, the mesorectal fascia is carefully separated from the pelvic plexus while ensuring that the distal mesorectum and rectum are fully detached from the neurovascular bundle and pelvic plexus. Upon full mobilization of the rectum, the pelvic floor, including the puborectalis and pubococcygeus muscles, as well as the anal hiatus, is clearly exposed.

4. Summarized Special Issues

The 7-step procedure, known as the Rainbow Step by Step Approach, should be followed. In addition, based on personal study and experience, we would like to address a following issues.[5,8,9]

4.1. Customized DVF excision

It has been observed that some male and most female patients have a thinner mesorectum compared with the lateral or posterior mesorectum.

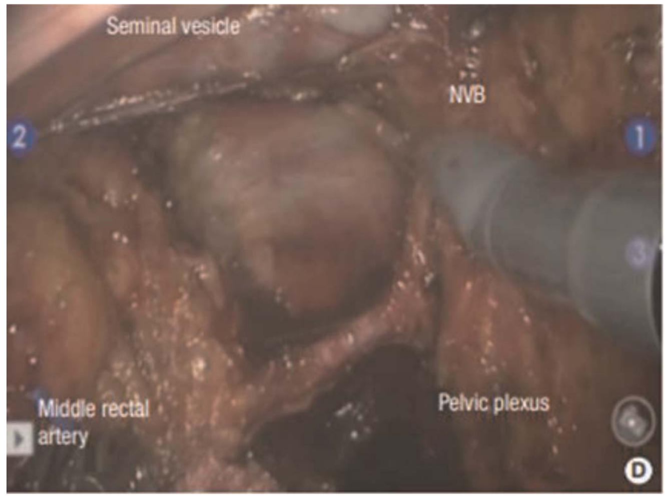

Figure 8. The robot surgery view showed the clear identification of the middle rectal artery. Dissection was performed posterior to the DVF, and the neurovascular bundle was subsequently well-preserved. The middle rectal artery was found near the pelvic plexus. SV, seminal vesicle; NVB, neurovascular bundle; MR, mesorectum; PP, pelvic plexus; MRA, middle rectal artery. Reproduced from Lee and Kim. *Ann Coloproctol*. Apr 2018;34 (2):59–71, with permission.[7]

As a result, anteriorly located rectal cancer, especially cT3 tumors with a thin mesorectum, tend to have a higher positive circumferential resection margin. In addition, the anterior part of the rectum is known to be difficult to expose during surgery.

Previous studies have shown that anteriorly located rectal cancer has poorer oncologic outcomes compared with other types of rectal cancer. Lee et al[22] reported that locally advanced anteriorly located male rectal cancer had a higher risk of recurrence compared with other types of rectal cancer. Therefore, it is recommended that preoperative chemoradiation therapy be used more frequently for anteriorly located rectal cancer compared with tumors in the lateral or posterior quadrant of the rectum.[22]

Later, Kang et al[23] also reported that the circumferential resection margin positive rate was higher for anteriorly located rectal cancer compared with nonanteriorly located rectal cancer. A multivariate analysis showed that an anterior tumor was the only independent risk factor for a positive circumferential resection margin.[23]

Because the anterior mesorectum is thin, if the tumor invades the rectal wall and penetrates the mesorectum, it is difficult to expose the anterior part of the rectum after the anterior peritoneum has been incised because it is close to the mesorectal fascia.

The role of the DVF in achieving a negative circumferential resection margin during anterior pelvic dissection has been controversial.[24–27] The opinions on whether to dissect in the anterior or posterior surgical plane vary among colorectal surgeons. Cadaver studies show that the DVF has multiple layers and is loosely attached to the seminal vesicle but densely attached to the prostate and descends to the perineal body. The neurovascular bundle goes down to the genitalia along the seminal vesicle and prostate in the 10 and 2 o'clock directions outside the DVF.[11,20]

Therefore, in cases where the tumor is cT2 and located anteriorly, or cT3 and located laterally or posteriorly, it is recommended to perform appropriate anterior dissection behind the DVF until reaching the pelvic floor (Fig. 11A). If the tumor is cT3 or cT4 and located anteriorly, the excision of the DVF should be customized based on the tumor level. For a cT3 tumor located anteriorly at the level of the prostate, proper anterior dissection should be performed behind the DVF at the level of the seminal vesicles but switched to anterior to the DVF at the level of the prostate (Fig. 11B). However, if there is a long segment of a cT3 tumor extending from the seminal vesicles to the prostate gland, proper anterior pelvic dissection should be performed anterior to the DVF (Fig. 11C).

This customized concept for DVF excision in anteriorly located rectal cancer, according to tumor level and tumor depth of invasion, is proposed for the optimal oncologic and functional outcome in TME procedures.[28,29]

4.2. Safe mobilization of the lateral wall of the rectum

Safe mobilization of the rectum's lateral wall is crucial to prevent injury to the pelvic plexus and ensure the preservation of the mesorectum's integrity, thus avoiding a positive circumferential resection margin.

4.3. Safe management of the middle rectal artery

Proper management of the middle rectal artery is also critical, as rough traction and mass ligation for bleeding control can cause damage to structures in the surrounding area if not done correctly. Because the middle rectal artery's trajectory penetrates the pelvic plexus, ligation of the middle rectal artery increases the risk of mechanical or thermal injury to the autonomic pelvic nerves. A sufficient distance from the pelvic plexus is required for adequate control of the middle rectal artery.

The middle rectal artery and pelvic plexus are critical structures that must be preserved during TME surgery (Fig. 12). The middle rectal artery's exposure is critical, and depending on its size, it can be controlled using electrocautery, energy devices, or vascular clips. The Gate approach is an effective method for exposing the middle rectal artery while keeping the pelvic plexus intact. The rectum and mesorectal fascia are mobilized along the embryological plane from the pelvic wall, beginning behind the parietal fascia on the lateral side and detaching from the mesorectal fascia.[30]

This dissection proceeds to the deep pelvic floor, leaving the lateral attachment and upper connective tissue layer hanging like a bridge between the parietal and mesorectal fascias, allowing the middle rectal artery to be ligated while the pelvic plexus is preserved.

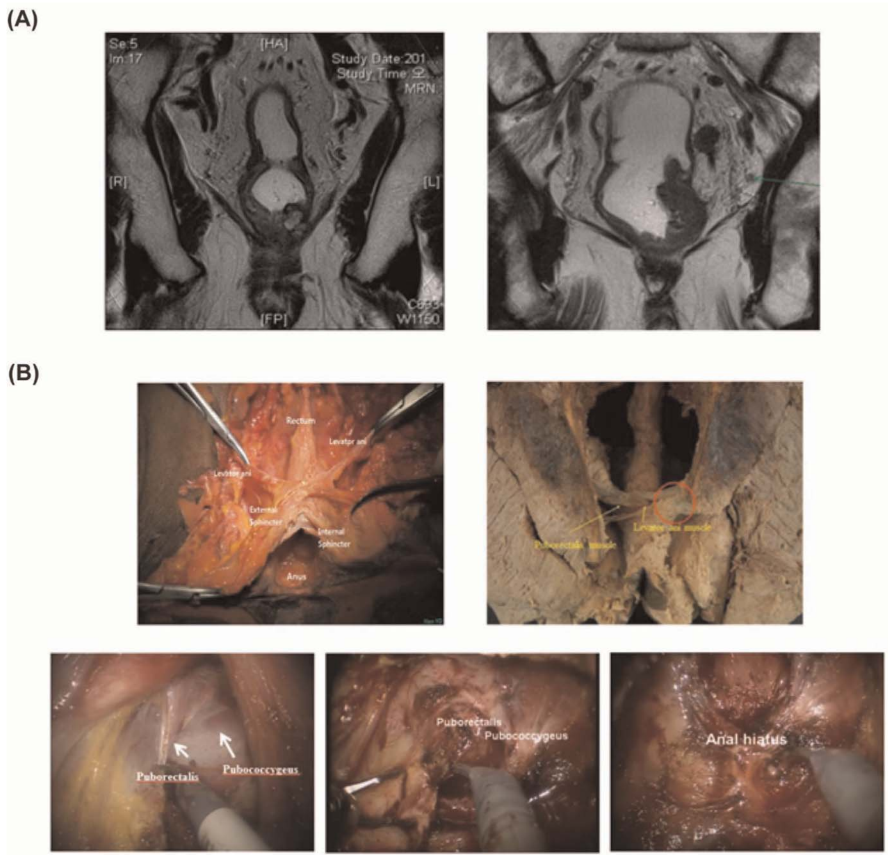

Figure 9. A, Coronal view of T2-weighted rectal magnetic resonance imaging revealed the relationship between the mesorectum and the pelvic floor. The shape of this relationship varied depending on sex. B, The cadaveric specimen displayed a funnel-shaped pelvic floor (above). The robotic surgery view showed the puborectalis muscle and pelvic floor (below). Reproduced from Lee and Kim Ann Coloproctol. Apr 2018;34 (2):59–71, with permission.[7]

4.4. Gate approach

The Gate approach involves dissecting the anterolateral part of TME behind the DVF, starting from the seminal vesicle or lateral side of the vagina to the lateral part of the mesorectum. The dissection should continue deeply until reaching the pelvic floor, creating an easy and clear gate between the mesorectal fascia and the pelvic floor.

In this approach, the rectum and mesorectal fascia should be mobilized from the pelvic wall along the embryological plane, starting behind the parietal fascia on the lateral side and detaching from the mesorectal fascia. This dissection should progress to the deep pelvic floor, leaving the lateral attachment and upper connective tissue layer hanging like a bridge between the parietal and mesorectal fascia. This allows for ligation of the middle rectal artery while preserving the pelvic plexus.[14]

From a surgical standpoint, performing deep rectal mobilization with the Gate approach facilitates the identification of the condensed connective tissue forming the lateral ligament during anterolateral dissection. It also helps in visualizing different variations of the middle rectal artery, if present, while preserving the pelvic autonomic nerve plexus.

4.5. Abdominoperienal resection and rectourethralis muscle, perineal body

Young surgeons may struggle to identify anatomical landmarks for both oncologic and functional safety during perineal dissection. Posterior or posterolateral dissections, which involve the excision of attached the levator ani muscles, can be particularly difficult during anterior dissections, when there is a high risk of circumferential resection margin—positive in anteriorly located rectal cancers as well as urethral injury or rectal perforation. The rectourethralis muscle can be used as an anatomical landmark to avoid these complications. The rectourethralis muscle should be saved unless the tumor is on the anterior rectal wall.

To accomplish this, the dissection should remain posterior to the DVF until the prostate level during the transabdominal approach and anterior pelvic dissection. Previous anatomical studies have revealed that the DVF descends to the perineum and terminates at the rectourethralis muscle. As a result, the dissection should continue posterior to the DVF, with the rectourethralis muscle intact and separated from the urethra and rectum. Young surgeons are advised to study anatomy and embryology to improve their surgical skills.[31–33]

5. Discussion

In 1986, Professor Heald reported an exceptionally low recurrence rate in 115 patients who underwent excision of the rectum and the posterior elements of the endopelvic fascia, naming his technique TME.[5] Since then, TME has been widely regarded as the standard surgical treatment concept for rectal cancer eradication worldwide. In the case of locally advanced rectal cancer in the lower rectum, various treatment approaches, such as upfront systemic chemotherapy, chemoradiotherapy, or postoperative chemotherapy, have been proposed. Recently, the PROSPECT clinical trial demonstrated that preoperative FOLFOX

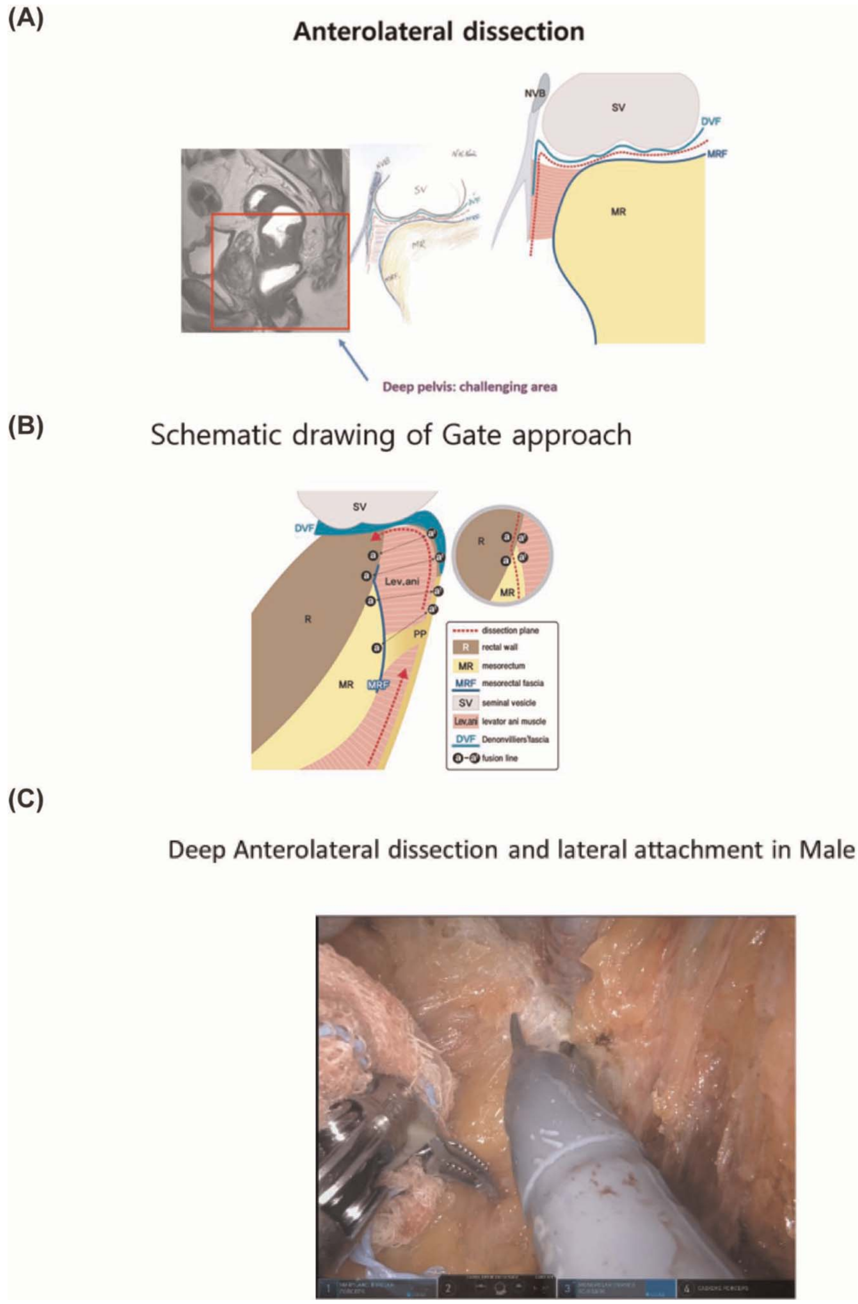

Figure 10. A, A red dotted line indicated the proper dissection plan behind the DVF. This is the way to obtain a complete TME specimen, but it is also the most difficult step of the procedure. B, A schematic image of the Gate approach is one way to obtain a complete TME specimen in a deep narrow pelvic cavity. C, Video clips demonstrating the Gate approach.

chemotherapy is noninferior to preoperative chemoradiotherapy in terms of disease-free survival.[34] The trial randomized patients into the FOLFOX group (585 patients) and the chemoradiotherapy group (543 patients) with a median follow-up of 58 months. The 5-year disease-free survival rates were 80.8% in the FOLFOX group and 78.6% in the chemoradiotherapy group, with no significant difference in local recurrence between the 2 groups. These results demonstrated the noninferiority of neoadjuvant FOLFOX chemotherapy with selective use of chemoradiotherapy compared with the current standard of chemoradiotherapy in terms of local recurrence and 5-year disease-free survival rates, albeit limited to patients with T2 node-positive, T3 node-negative, or T3 node-positive rectal cancer who were candidates for sphincter-sparing surgery. As mentioned in introduction, the so-called total neoadjuvant therapy (TNT) trial such as RAPIDO and PREDIGE 23 has been introduced to improve the oncologic and functional outcomes for locally advanced rectal cancer. Alongside these advancements in treatment, new surgical modalities have emerged, including minimally invasive techniques like transanal TME. These developments reflect the ongoing pursuit of improved surgical approaches in the field of rectal cancer treatment.

Total mesorectal excision, with or without neoadjuvant chemoradiotherapy, allows for curative resection in a significant number of patients

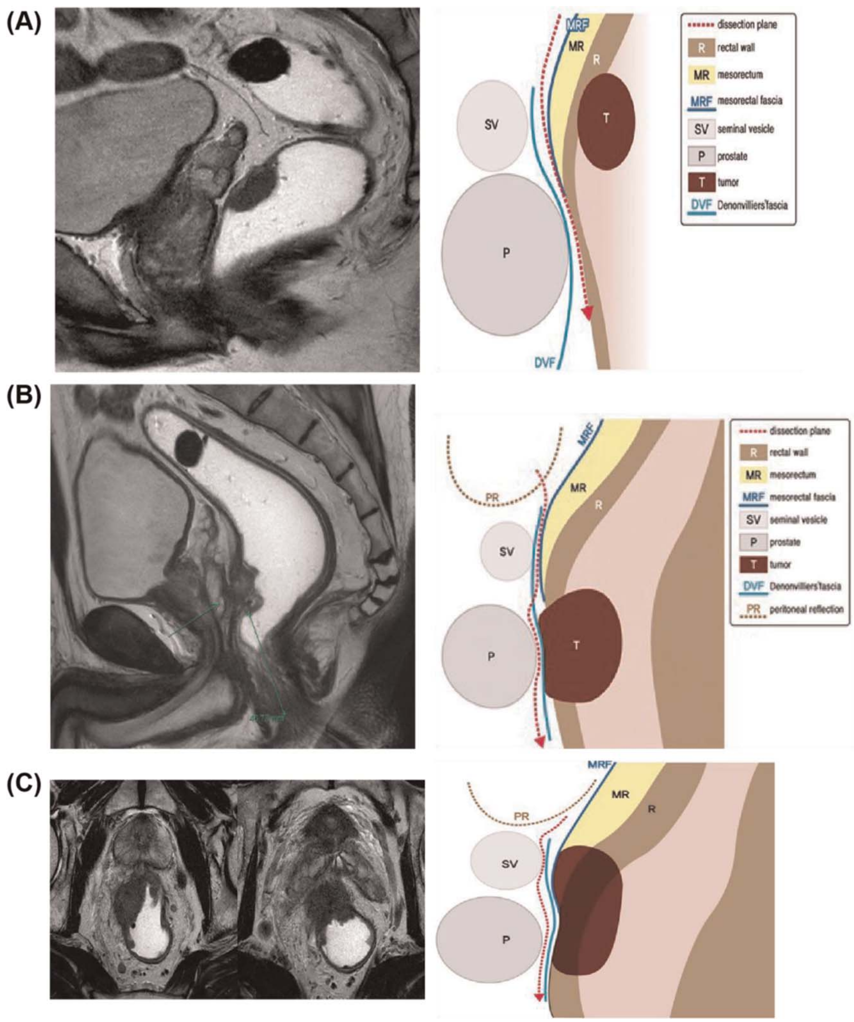

Figure 11. A, The sagittal T2-weighted image showed a cT2 tumor without mesorectal fat invasion at the seminal vesicle level. Schematic images of the dissection plane in the anterior dissection were also shown. B, The sagittal T2-weighted image showed an anteriorly located rectal cancer at the level of the prostate gland, abutted to the prostate gland capsule. Initially, the dissection began posterior to the DVF and switched to the anterior to the DVF at the prostate gland. C, The sagittal T2-weighted image showed an anteriorly located tumor present from the seminal vesicle to the prostate gland, abutted to the seminal vesicle and prostate gland. Anterior dissection to the DVF should be done from the seminal vesicle to the prostate gland to get negative circumferential resection margin.

with rectal cancer. However, in cases of locally advanced rectal cancer with invasion into adjacent structures, achieving R0 resection through dissection along the embryologic plane becomes impossible. Recently, researchers have proposed the concept of compartment-based pelvic anatomy to address the challenges of resecting locally advanced rectal cancer and dealing with involvement of surrounding tissues or organs. Extenterative surgery represents the sole method for obtaining a tumor-free margin, extending beyond the principles of TME. The work of Stelzner et al[35] presented a pelvic compartment classification based on 13 formalin-fixed pelvis specimens. The study systematically approached the subject using seven compartments defined by magnetic resonance imaging, identifying crucial anatomical landmarks and key structures that facilitate pelvic exenterative surgery.[35] These compartments include the peritoneal reflection compartment, anterior compartments (above and below for both males and females), central compartment, lateral compartment, posterior compartment, and inferior compartment. It is important to note that beyond TME surgery is typically performed by highly specialized teams who possess a thorough understanding of pelvic compartments and the options and limitations of extended surgical procedures. Knowledge of pelvic anatomy, as well as the subdivision of the pelvis into these 7 compartments based on magnetic resonance imaging, is an essential prerequisite for minimizing complications and achieving R0 resection.

These new treatment concepts and techniques continue to emerge, and surgical intervention performed by colorectal surgeons remains the cornerstone of rectal cancer treatment. It is crucial not to underestimate the significance of conventional TME surgery, as it still continues to play a vital role in the management of a substantial number of rectal cancer patients. Moreover, it is imperative for young surgeons to master the techniques of TME. A comprehensive understanding of TME and proficiency in its step-by-step surgical techniques are essential for ensuring optimal oncologic and functional outcomes.

6. Conclusion

Precise understanding of pelvic surgical anatomy is crucial for achieving optimal dissection during pelvic surgery, ensuring both oncologic and functional safety. With the introduction of minimally invasive surgery, including magnified views and even 3D imaging of the pelvis, surgeons are now able to examine the anatomy more comprehensively. This enhanced

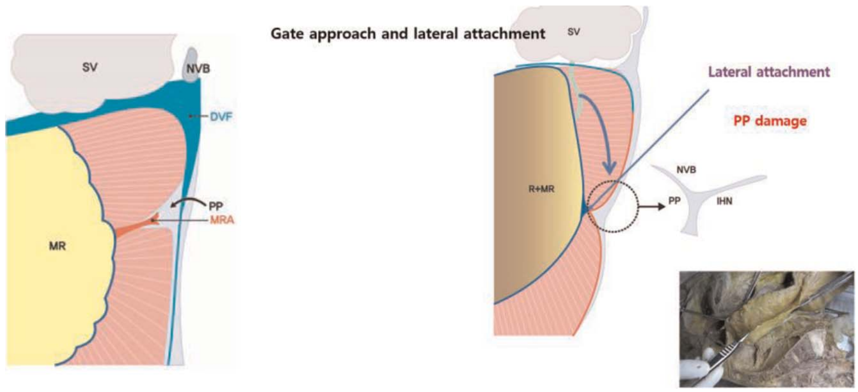

Figure 12. The schematic image shows the relation between the middle rectal artery and the pelvic plexus. Proper exposure to this area is crucial to prevent bleeding and injury to the pelvic plexus.

visualization allows for deliberate and precise surgical dissections, ultimately leading to improved functional outcomes and successful curative resections. In this article, we presented our own technical tips, such as the pelvic dissection sequence, Gate approach, and customized DVF excision, to assist surgeons in performing high-quality rectal cancer surgeries. In addition, we emphasize the importance of gentle dissection with traction or counter traction techniques. Drawing from our clinical experience, insights, and previous studies, we have summarized these techniques and provided insights to help guide young surgeons toward achieving optimal surgical outcomes. By staying up-to-date with advancements in surgical techniques and incorporating these insights into their practice, young surgeons can enhance their surgical skills and contribute to improved patient outcomes in rectal cancer surgery.

Data availability statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Conflicts of interest statement

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