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HOW I DO IT

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# Minimally invasive rectal surgery: Laparoscopy, robotics, and transanal approaches

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## 1 | INTRODUCTION

The management of rectal cancer is constantly evolving. Some of the recent changes in rectal cancer management are directed toward the sequencing of multidisciplinary treatment including the use of total neoadjuvant therapy which incorporates neoadjuvant radiation and neoadjuvant chemotherapy before surgery.[1,2] Moreover, the concept of overtreatment in rectal cancer has lead to investigations on the selective use of radiation and as well as the concept of nonoperative management of rectal cancer.[3-5] The incorporation of these various approaches to rectal cancer management has enabled physicians to apply more personalized treatment algorithms, rather than sweeping generalizations. This concept of personalizing rectal cancer treatment is not lost on the approach to surgical resection.

Following the development and implementation of the total mesorectal excision (TME) in rectal cancer, the continued evolution of minimally invasive surgical techniques leads to the application of this technology to patients undergoing proctectomy for rectal cancer. The utilization of minimally invasive surgery (MIS) in rectal cancer has been studied in multiple national and international randomized trials.[6–9] These trials have demonstrated that the approach of MIS for rectal cancer yields similar oncologic outcomes to open surgery in terms of disease-free and overall survival.

The introduction of robotic-assisted laparoscopic technology added another option for the surgical management of rectal cancer. Many retrospective studies have demonstrated the efficacy of this technique.[10–12] There is only one randomized controlled trial comparing laparoscopic to robotic-assisted laparoscopic proctectomy. It was designed to determine if robotic-assisted laparoscopic surgery had a lower rate of conversion to an open procedure when compared with standard laparoscopy. No differences in this primary outcome were identified between the two minimally invasive techniques.[13]

Beyond the introduction of robotic-assisted surgery, others have also begun examining alternative technical approaches, including laparoscopic transanal TME. This particular technique has a steep learning curve and has introduced some unique associated potential morbidity. As a result of a few associated challenges with this technique, it has presented a unique opportunity for conceptualizing education of new rectal surgery techniques.[14,15]

Despite the variety of options that currently exist for technical approaches to surgical resection of rectal cancer, there remain essential components of the operation that need to be maintained. These critical steps may be done in various sequences, but regardless of the order, the components remain constant. This article will outline the essential steps to minimally invasive proctectomy for rectal cancer with a focus on robotic-assisted laparoscopic surgery. The technical approaches and strategies to maintain essential oncologic surgical principles will be reviewed. In addition, strategies to help teach these procedures to the next generation of rectal cancer surgeons will be highlighted.

## 2 | PATIENT SELECTION

While not directly related to technique, patient selection for MIS is important to help ensure success. There are general criteria to consider when selecting patients for MIS. In the setting of elective surgery, there are few relative contraindications such as obesity and extensive prior surgeries. Beyond physical characteristics, there are relative oncologic contraindications. Specifically, patients with T4 rectal tumors and those requiring beyond TME resections require special consideration. Although there have been extensive randomized control trials performed that examine the role of MIS in the surgical management of rectal cancer, patients with T4 tumors and beyond TME resections were excluded.[6-9] Therefore, while there are publications reporting retrospective experiences and outcomes in these select populations in single-institution experiences, it must be approached with caution and should still be considered experimental. Oncologic surgical principles, including margin negative resection, cannot be compromised and that risk is significantly increased in tumors requiring extended or multivisceral resections. Therefore, these types of more radical minimally invasive surgeries should not be considered the standard of care.

## 3 | OPERATIVE SETUP

For robotic-assisted proctectomy, the patient is positioned in lithotomy. It is essential to ensure proper positioning and padding of the legs to provide adequate access for the robotic arms and avoid injury. In addition, both arms are tucked and also carefully padded. This provides access for the assistant to be close to the bedside and enables room for the robot to dock. As with any procedure requiring tucking of the arms, it is essential to ensure the patient is secured and that the intravenous access and arterial lines are functional before prepping and draping. The robotic patient cart is then brought in over the left hip (Figure 1A,B). This position enables the boom to be rotated to provide excellent access to the pelvis as well as the splenic flexure in a two-dock approach. Alternatively, in a single-dock approach, this position provides the greatest versatility for multiquadrant surgery. The tower is positioned off the patient's left shoulder.

When selecting instruments there are several options available to help execute the operation. Basic instruments for routine setup include monopolar scissors, a fenestrated bipolar grasper, and a prograsp retractor. These instruments enable sufficient flexibility to navigate the steps of robotic proctectomy. Alternatives include the Maryland bipolar and the tip-up fenestrated grasper. In most cases, the vessel sealer will also be utilized for the division of the mesentery, assistance with the splenic flexure mobilization and division of the mesorectum when performing a tumor-specific mesorectal excision. The use of the robotic stapling device has advantages for proctectomies requiring division in the low pelvis. The robotic stapler does require a larger port (12 mm) that has an 8 mm reducer to continue to enable flexibility of the instruments before using the stapler.

## 4 | OPERATIVE STEPS

### 4.1 | Abdominal access/port placement

Port placement is a critical step for any minimally invasive procedure. There are a number of options for setting up ports for robotic proctectomy. However, the approach presented here includes two basic setups for the ports to provide access for both a single-dock and dual-dock approach. The first provides a very consistent setup for the robotic arms to both minimize collisions and maximize access to the pelvis and the splenic flexure (Figure 1A). This basic setup lines up the ports in a horizontal line just superior to the umbilicus. The camera port is placed above the umbilicus. Two additional robotic ports are placed in the left midclavicular line and in the left anterior axillary line. The last robotic port is placed in the right midclavicular line. This will be the location of the stapler port if using that device. Two assistant ports can then be placed in the right anterior axillary line and in the right upper quadrant. As noted, this port setup will require a second docking after rotating the boom to mobilize the splenic flexure.

The second setup is an adjustment that permits the surgeon to perform the proctectomy and mobilization of the splenic flexure in a single dock of the robot (Figure 1B). This port setup can risk increased collisions and, in some circumstances, difficulty reaching

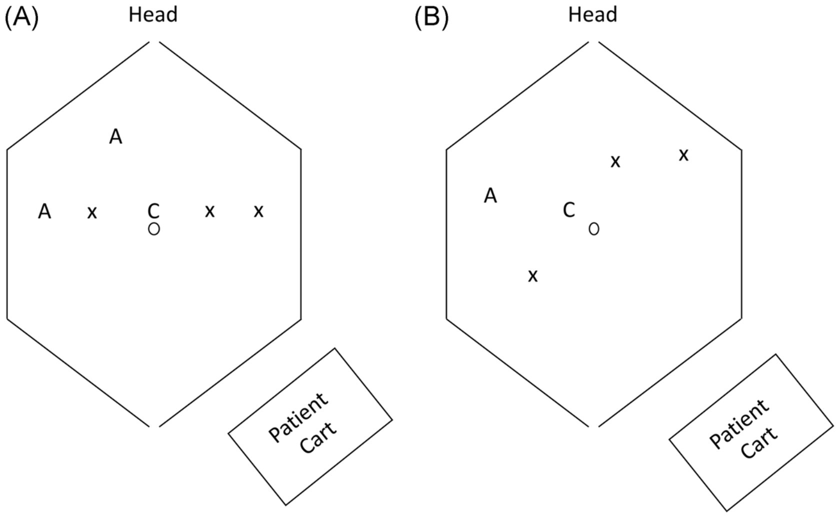


**FIGURE 1** Port placement for robotic proctectomy. The images depict the operative setup for robotic-assisted laparoscopic proctectomy where C represents the camera and A represents assistant ports. A, The port positioning for a dual-dock approach where the lymphovascular dissection and total mesorectal excision are conducted with the robot docked toward the pelvis. The robot was redocked and the splenic flexure was completely mobilized. B, The port setup for a single-dock approach. Using these positions, the robot is docked over the left hip and all of the steps of the operation are conducted without redocking the robot

the very low pelvis. It also has only one assistant port so can be more difficult in more obese patients where bedside assistance is more critical for exposure. This setup involves moving the camera more lateral and superior to the umbilicus on the right side. The right robotic port is placed in the right lower quadrant with the other two left ports in the epigastrium and in the upper left quadrant. The assistant port is placed in the upper right quadrant. This tilting of the access to have the ports run from the lower right quadrant up to the upper left quadrant provides extended access to the left hemiabdomen. With this technique, the proctectomy and the splenic flexure mobilization will occur without redocking the robot.

## 4.2 | Lymphovascular dissection

Lymph node harvest remains a quality metric when assessing the performance of colon and rectal cancer operations. The extent of the proximal dissection for oncologic benefit remains debated. Specifically, high ligation of the inferior mesenteric artery (IMA) above the takeoff of the left colic artery serves two purposes. The first is to remove at-risk lymph nodes. The second and likely more important is to provide adequate length for reconstruction. The mesenteric attachments are the limiting factors in allowing the colon to reach the low pelvis for an anastomosis. There are a number of ways to manage the proximal IMA, including simple division, resection of the lymphatic tissue while preserving the left ascending colic artery, and similarly resecting lymph nodes but preserving the central vascular arcade.[16]

There are several important technical considerations to be mindful of regardless of the approach to the proximal IMA. First, it is essential to identify the ureter early while accessing the plane between the mesocolon and the retroperitoneum at the level of the sacral promontory. This ensures the surgeon that the right plane has been accessed. Further dissection laterally will reveal the gonadal vessels. Once the ureter is identified, the dissection proceeds more proximally along the superior hemorrhoidal vessels toward the IMA origin. There are no anatomical arterial branches that arise from the anterior surface of the IMA, which enables safe dissection and removal of the lymphatic tissues of the ventral surface. Once the ventral surface is exposed, the artery can be dissected circumferentially. The hypogastric nerves do course lateral to the IMA in the retroperitoneum. A window exists medial to the hypogastric nerves as you approach the origin that enables the IMA to be isolated and divided without disturbing the relevant neurologic structures (Figure 2). The technique for control and division of the vessel varies. However, our approach is to divide it between clips, as opposed to using the vessel sealer for the division.

Once the vessel is divided, the operating surgeon can better visualize the nerves and dissect them free from the mesentery (Figure 2). This portion of the dissection is aided by establishing the plane underneath the inferior mesenteric vein (IMV) along the anterior surface of Gerota's fascia. This process helps define the area of lymphatics and the IMA as they transition from the retroperitoneum to the mesocolic plane. Finally, the IMV is also divided. This is typically done with the vessel sealer. It is important to remember that for complete mobilization of the

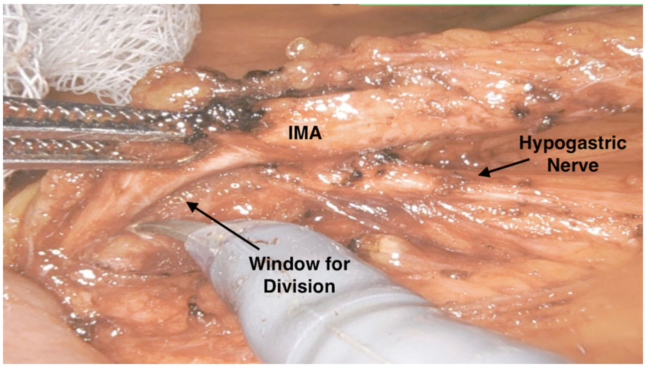


**FIGURE 2** Dissection of the inferior mesenteric artery (IMA). Dissection the proximal IMA medial to the hypogastric nerves enables the division of the vessels and then subsequent dissection of the nerves from the mesocolon. The window for transection is noted [Color figure can be viewed at wileyonlinelibrary.com]

flexure and the colonic mesentery, it is best to isolate and divide the vein close to the inferior border of the pancreas and proximal to the splenic flexure branch of the IMV.

## 4.3 | Colonic mobilization

Essential to any colon and rectal operation is providing adequate length for reconstruction. In addition, mobilization of the descending and sigmoid colon is a critical step to provide access to the left side of the pelvis. It will also enable the colon and rectum to be retracted out of the pelvis which is the necessary maneuver to safely navigate the TME plane for proctectomy. As with other minimally invasive surgical techniques for colon surgery, the dissection robotically proceeds in a medial to lateral fashion first elevating all of the mesocolons off of the retroperitoneum over to the abdominal wall laterally and superiorly up toward the pancreas. The more dissection that is done underneath the mesocolon, the easier the dissection is from the lateral approach to complete the mobilization. Any attachments of the sigmoid colon laterally are taken down with a combination of sharp dissection and cautery. This is carried up along the descending colon as far as possible toward the splenic flexure.

## 4.4 | Mesorectal excision

The dissection in the TME plane is at the heart of rectal cancer surgery. Successful completion of this step of the operation is aided by initiating the dissection in the correct plane at the level of the sacral promontory. The areolar tissue is easily found at this location. However, as the dissection starts, one must be careful to proceed on the anterior surface of that areolar tissue toward the mesorectal fascia. This helps avoid a common pitfall of dissecting into the presacral soft tissues which can lead to bleeding. Dissecting first in the posterior plane enables the better definition of the lateral portions of

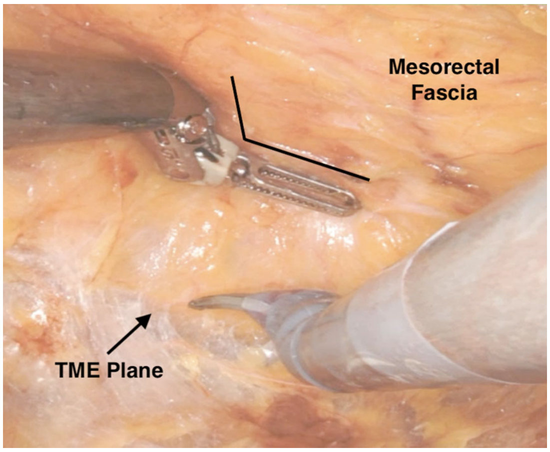


**FIGURE 3** Retraction in the pelvis for total mesorectal excision (TME). The fenestrated bipolar is shown in an "L" shape. This provides a broad interface between the tissue and the instrument. It enables the mesorectum to be retracted anteriorly and out of the pelvis exposing the TME plane while avoiding damage to the mesorectal fascia [Color figure can be viewed at wileyonlinelibrary.com]

the mesorectal dissection. At this point, the prograsp retractor is used to elevate the distal sigmoid colon up against the abdominal wall. The fenestrated bipolar is then used to create traction in the mesorectal plane. This is done by creating a right angle "L shape" with the fenestrated bipolar (Figure 3). This creates a large, blunt surface area to elevate the mesorectum anteriorly and also create come traction to lift the mesorectum up out of the pelvis. The hot scissors are then used to dissect in the posterior plane as distally as possible.

After having dissected the upper portion of the pelvis posteriorly, the lateral attachments are taken down with cautery as well. The remainder of the TME dissection is aided by having your assistant retract the rectum up and out of the pelvis. To help, and avoid slippage, we use a ray tec and tie it around the upper rectum to minimize trauma to the mesorectum and bowel while allowing the bedside assistant to use a locking grasper to hold onto the ray tec. The key principle of performing a TME is being able to pull the rectum up and out of the pelvis. This is true for open proctectomy and it remains constant for minimally invasive procedures. The only way to achieve that is to begin working circumferentially.

By incising the peritoneal reflection anteriorly, you can better visualize the means to connect the posterior dissection anteriorly on both sides. This will also enable better exposure in the pelvis as the rectum and the mesorectum will begin to become mobile and can be retracted out of the pelvis. During this portion of the dissection, the prograsp can be used to retract anteriorly by lifting the peritoneum over the seminal vesicles or by retracting the uterus anteriorly. Simultaneously, the assistant can then retract the rectum out of the pelvis and direct additional exposure through anterior or lateral retraction. The fenestrated bipolar is used to continue to bluntly manipulate the mesorectum to create traction for continued dissection along the mesorectal fascia down to the pelvic floor.

For true TME dissections removing all of the mesorectums, it is essential to divide Waldeyer's fascia posteriorly to expose the bare rectum and enable an appropriate application of the stapler. If there is any question on tumor location, the tumor is localized endoscopically before applying the stapler to ensure an adequate distal margin. The robotic stapler is then oriented anterior to posterior for divisions near the pelvic floor. It routinely takes two loads of the stapler to achieve division. Anecdotally this remains true even when using a 60-mm stapler.

## 4.5 | Splenic flexure mobilization

For all rectal surgery (with few exceptions), mobilization of the splenic flexure should be considered a standard portion of the procedure. This enables the anastomosis to be created without tension and often allows for use of the more proximal sigmoid colon and or descending colon for the anastomosis. As with the lymphovascular dissection, there are different approaches to the mobilization of the splenic flexure and being familiar with each is helpful and provides options for the more difficult flexures. In the traditional port placement (Figure 1A), the robotic arms are undocked and the boom is rotated. The patient is repositioned in reverse Trendelenburg. This allows gravity to help assist with the colonic retraction. The robot is redocked and the camera remains in the same position, but the hot scissors are typically placed in the midclavicular port on the patients left and the prograsp remains in the far left port. The fenestrated bipolar is placed in the right midclavicular port. Alternatively in the single-dock approach, the mobilization of the flexure is done with the fenestrated bipolar and either hot scissors or the vessel sealer. In this setup, the prograsp is only used to retract the colon toward the pelvis while the assistant helps to manipulate the colon.

The two main approaches include an inframesocolic approach and the antecolic approach. The antecolic approach is most similar to the open technique for mobilization. The omentum is elevated and reflected off of the transverse colon providing access to the lesser sac. This is continued laterally out to the splenic flexure. The prior lateral colonic mobilization plane is then accessed and with cautery or the vessel sealer, the attachments of the transverse mesocolon to the inferior border of the pancreas are divided continuing medially to the stump of the IMV.

The inframesocolic approach is unique in that it is utilized only for minimally invasive techniques for splenic flexure mobilizations. After the IMV is divided, the mesocolon is separated from the inferior border of the pancreas with cautery. The dissection continues medially over the pancreas and into the lesser sac (Figure 4A). The mesocolic attachments to the inferior border of the pancreas can then be divided with the vessel sealer continuing out to the splenocolic ligaments. This is also typically aided by additional assistance from the bedside assist to elevate the mesocolon and expose the lateral mobilization plane from underneath the mesocolon (Figure 4B). Once these attachments are all divided, then the omentum is reflected off of the transverse colon to complete the mobilization of the splenic flexure.

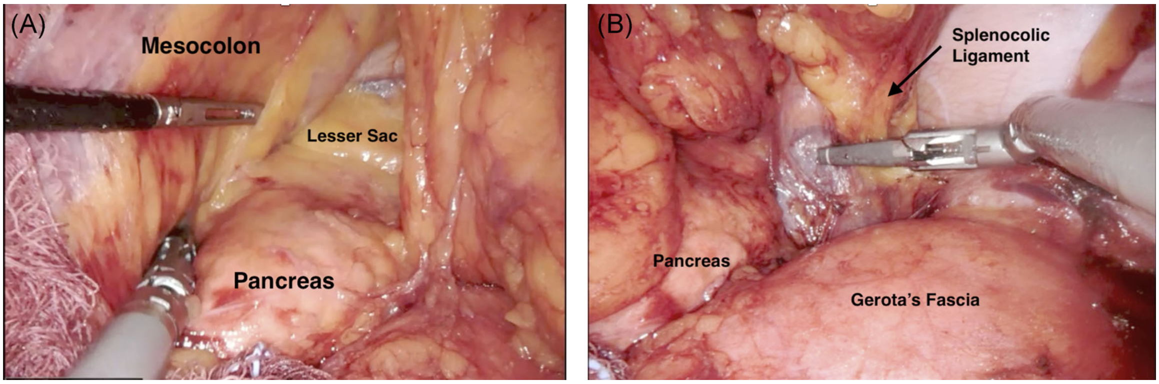


**FIGURE 4** Inframesocolic approach to the splenic flexure. A, The approach over the pancreas to access the lesser sac. The pancreas is down, the mesorectum is retracted anteriorly and cranially exposing the lesser sac. B, As the dissection continues, the remaining splenocolic ligaments can be divided using the vessel sealer [Color figure can be viewed at wileyonlinelibrary.com]

### 4.6 | Specimen extraction and anastomosis

Following the completion of the pelvic dissection and mobilization of the colon and the splenic flexure, the mesentery is then divided with the vessel sealer. Typically, the stump of the IMA and the IMV is included with the specimen. This is continued out to the colon at a location determined for the anastomosis. A Pfannenstiel incision is then created for the extraction of the specimen and preparation for the anastomosis. A wound protector is placed and the specimen is extracted. The specimen is most easily removed by starting at the stapled end of the rectum. Adequate length is then confirmed for the anastomosis. The proximal colon is then divided. Pulsatile blood flow is confirmed with either visualized pulsatile bleeding or audible doppler signal or palpable pulse in the marginal artery.

Once the specimen is removed it should be taken to pathology for gross inspection of the completeness of the mesorectum and for margin assessment. The anastomosis is created using an end-to-end anastomosis stapler. The anvil of the stapler is secured in the proximal colon with a purse-string suture. Pneumoperitoneum is then reestablished by occluding the wound protector. The stapler is introduced into the rectum and the spike is brought out just lateral to the staple line ideally close to the location of the junction of the two fires of the robotic stapler. The anvil is connected and closed. It is essential to ensure the colon is still properly oriented and not twisted. The stapler is fired and removed. The donuts are examined for completeness. The proximal colon is occluded and the pelvis filled with saline. The anastomosis is visualized endoscopically and insufflated for an air leak test.

## 5 | EDUCATIONAL PRINCIPLES

Teaching robotic surgery can be seen as more challenging than some other minimally invasive techniques. This is due in large part to the geographic differences that exist in robotic surgery. In other words, the operating surgeon is not at the table. For some surgeons and trainees, this can be seen as an obstacle to education. These obstacles can be overcome by additional assistance in the operating room in the form of a bedside assistant. In addition, the availability of a dual console can also enhance the educational experience. None of these things are required and high-quality education and teaching can be achieved in the absence of these resources, but it requires more commitment from the teaching faculty.

Understanding the steps of the operation and their role as well as the level of complexity provides a nice framework to conduct surgical education. This has been demonstrated in other surgical procedures.[17,18] All educational experiences are enhanced by clearly defined learning objectives. In the case of robotic-assisted laparoscopic proctectomy, utilizing the different steps to define the educational objectives of each case with the surgical trainee will be mutually beneficial. For robotic proctectomy, the least difficult step is the mobilization of the descending and sigmoid colon. This step allows for the surgical trainee to become familiar with the movements of the instruments and the concepts of blunt but active retraction to create exposure through manipulation of the wrists of the instruments. There are similar benefits to the learner with the mobilization of the splenic flexure. This step is a level up in terms of difficulty but can help the learner continue to gain confidence with the instruments, exposure, and technique.

After achieving competency in the execution of these steps, the surgical trainee is ready to move on to the lymphovascular dissection of the IMA and the TME dissection in the pelvis. These steps require competency with the basic concepts of robotic instrument manipulation to be done safely and efficiently. Certainly, approaching the IMA simply with plans to divide the IMA near its origin is the least complicated approach to start. It still requires dexterity with the instruments and careful dissection to avoid neurovascular injury. Obviously, preservation of the left ascending colic artery or preservation of the central vascular arcade is more involved technically but can be utilized as additional educational opportunities.

Finally, the TME dissection, while seemingly straightforward, has the most oncologic relevance in terms of a direct impact on risks for local recurrence. The trainee must recognize the plane of dissection and be able to manipulate the mesorectum for exposure without damaging the mesorectal fascia. This will then result in a complete mesorectal specimen that is correlated with the best oncologic result. This is perhaps even more impactful as concepts of selective use of radiation are increasingly utilized. Given the significance of this step, this dissection also merits that the trainee demonstrates competency with the other skills before proceeding with this step. Posterior dissection is the most straightforward and enables good experience to be gained with the proper plane of dissection before pursuing anterior and lateral dissections.

Outlining these steps of the operation with surgical trainees and providing supporting material including access to simulation and operative video review is essential. It provides them with a road map to achieve competency in the procedure while still maintaining principles of safety, oncology, and efficiency in the operating room. When a dual console is available together with an additional bedside assist the opportunity to exist to swap instruments between users. For educational purposes, this is invaluable as the techniques can be demonstrated and repeated by the trainees in terms of arm position, instrument manipulation, retraction, exposure, and plane identification.

## 6 | ALTERNATIVE MIS APPROACHES

Regardless of the technical approach to proctectomy, the steps of the operation remain constant. However, the order in which they are conducted may vary and, similarly, the technical approach may vary.[19,20] The most dramatic example of this is the transanal TME procedure. This technique is very different in its approach to the TME dissection as the plane is accessed transanally by suturing the rectum and dividing it under direct laparoscopic visualization.[14,21] This technique is unique in its visualization of the planes and requires specific expertise as it is different than any of the transabdominal approaches. This introduces some additional challenges to the educational landscape. However, given the associated challenges with this new approach, it has presented excellent opportunities for improving the educational approach. This has been a hallmark of the introduction of this technique in many countries including a standardized approach to training and implementation.[14,15]

## 7 | SUMMARY

Proctectomy for rectal cancer remains a challenging operation whether it is conducted open or using minimally invasive techniques. As for any operative procedure, experience, and repetition is critical to success. It provides an opportunity to maximize oncologic outcomes while simultaneously minimizing the potential morbidity. Familiarity with the defined operative steps for robotic-assisted laparoscopic proctectomy helps to set the stage for the education of the next generation of surgeons to help treat patients with rectal cancer.

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