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The Mesentery in Robot-Assisted Total Mesorectal Excision

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Abstract

In recent decades, surgery for rectal cancer has evolved from an operation normally performed under poor vision with a lot of blood loss, relatively high morbidity, and mortality to a safer operation. Currently, minimally invasive rectal procedures are performed with limited blood loss, reduced morbidity, and minimal mortality. The main cause is better knowledge of anatomy and adhering to the principle of operating along embryological planes. Surgery has become surgery of compartments, more so than that of organs. So, rectal cancer surgery has evolved to mesorectal cancer surgery as propagated by Heald and others. The focus on the mesentery of the rectum has led to renewed attention to the anatomy of the fascia surrounding the rectum. Better magnification during laparoscopy and improved optimal three-dimensional (3D) vision during robot-assisted surgery have contributed to the refinement of total mesorectal excision (TME). In this chapter, we describe how to perform a robot-assisted TME with particular attention to the mesentery. Specific points of focus and problem solving are discussed.

Keywords
- robot-assisted total mesorectal excision
- surgical technique
- mesentery

One of the exciting aspects in this era of the infancy of robot-assisted surgery is the opportunity to learn more about anatomy. For those who want to open up to new anatomical insights, superior vision, and meticulous dissection robot-assisted surgery may provide a wealth of discoveries and knowledge. The robot system provides a stable three-dimensional (3D), high-definition view controlled by the surgeon. Even the highest resolution, 3D laparoscopic set-ups do not overcome the limitations of the assistant controlling the camera, and hence the anatomical view. During laparoscopy, the assistant can make mistakes, get tired, and often might have a focus different from that of the operating surgeon. In contrast, the four-armed robot offers the surgeon autonomy and control over three instruments and the camera. The excellent and stable 3D view can reveal anatomical details not previously noticed during open or laparoscopic surgery. However, at the beginning of the learning curve, these details may be confusing, and the tiniest of structures may seem to be essential arteries or nerves.

In addition to the visual advantage, the robot permits dissection on a millimeter scale. The use of the wristed instruments such as scissors or cautery hooks enables the surgeon to access tissues normally difficult to access with rigid instruments, and thus enables the surgeon to adhere or stick to precise anatomical planes. These planes are often bordered by epithelial or mesothelial cell layers.[1] Neighboring cell layers are separated by loose, areolar connective tissue with or without lymphatic vessels, nerves, and blood vessels. The ideal dissection in colorectal surgery should be in this loose connective tissue, outside but along the subjacent epithelial or mesothelial cell layer. Essentially, colorectal surgery is surgery of planes. Here, the benefits of robot-

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assisted surgery and the anatomical challenges imposed by the rectal mesentery converge. With robot-assisted surgery, recent insights related to continuity and contiguity of the mesentery are more easily recognized and followed during surgery.[2] Rectal TME surgery, as any kind of intra-abdominal cancer surgery, should be performed within intact embryological compartments without entry into neighboring anatomical compartments. Jonnesco (in 1896) was probably the first to describe a plane of dissection around the perirectal fascia and comprised of loose areolar connective tissue; Heald popularized dissection along the “Holy Plane.”[3,4] The TME surgery concept strives to remove an intact ontogenetic rectal compartment consisting of the bowel and its adjoining mesentery, the mesorectum.[5] It is essential to maintain this compartment intact and prevent tumor spillage. Thus, the cell layers of mesothelial and epithelial cells of the mesorectum must remain intact. These cell layers border a complete TME specimen. They are recognized at the mesorectal side by a thin layer of connective tissue generating a nice shiny appearance to the specimen. In the literature, this boundary is referred to as the mesorectal fascia. This terminology may be confusing, as this layer cannot be recognized as a firm fascia as we know from the musculoskeletal system.

The boundary of the colon’s mesentery consists of a fragile mesothelial layer, as shown in 2014 by Culligan et al in a comprehensive histological and electron microscopic study.[1] This tiny layer of mesothelial cells extends to the rectum, borders the mesorectum, and contributes to the mesorectal “fascia.” In our experience, the resultant boundary can be visualized in patients in which too much ink has been used to tattoo the tumor to be resected. In these cases, the ink is fully retained in the mesorectum by the transparent mesothelial layer. Many studies on the layers surrounding the rectum have been published, and findings vary. Several fasciae have been described.[6,7] Based on our intraoperative findings, we speculate the fasciae described in cadaver studies are often an artifact of preservation and dissection methods. We speculate the fascia generally consists of varying levels of connective tissue with or without mesothelial cell layers. In our opinion, modern teaching of the anatomy of the rectum should no longer be delivered in the dissecting rooms but instead, during robotic surgery.

Trocar Positioning During Robotic TME

In robot-assisted TME surgery, careful positioning of the trocars is essential. Trocar positioning is crucial to enable the surgeon to reach the extremities of the mesorectum. Care is taken to position the trocars in such a manner as to avoid outside collision of the operating arms. For this reason, optimal trocar placement often depends on the type of robot used. Standardization of the positioning of the trocars with pre-incisional markings may be effective for the novice robotic surgeon. However, strict adherence to a prescribed marking system will cause problems in a substantial number of patients due to individual anatomy. The shape of the bony pelvis and pelvic floor determine the borders of the mesorectum, which vary between patients. Problems encountered by inadequate trocar placement differ between robot types, but in general certain rules apply. Trocar positioning has to be considered not only based on external body shape but also the radiologic findings. The surgeon should examine anatomical aspects of access to the pelvis on computed tomography (CT) scans and magnetic resonance imaging (MRI) as much as the oncological aspects of these. The angles of the bony cage formed by the pelvis determine the limits of trocar placement. Unfortunately, the arms of several types of robots are numbered in different manners, not always corresponding with the order of introduction.

The positioning of the trocars is shown in ►**Fig. 1A, B**. The first trocar to introduce is the camera trocar. The camera’s standard positioning is 2 to 3 cm cranial and 2 to 3 cm to the right of the umbilicus if the umbilicus is the midpoint between the pubic bone and the xiphoid. However, this often is not the case. An option is to first create a pneumoperitoneum with a Veress needle at Palmer’s point (in the left upper quadrant 2–3 cm below the costal margin and the midclavicular line). This helps in deciding the optimal trocar introduction site. The use of a 30-degree camera overcomes most problems with inadequate positioning. A too cranial positioning of the camera may be problematic in the case of a very prominent sacral promontory. The latter occurs in the elderly with degenerative diseases such as osteoarthritis. In these rare cases, the first cranial part of the mesorectum’s

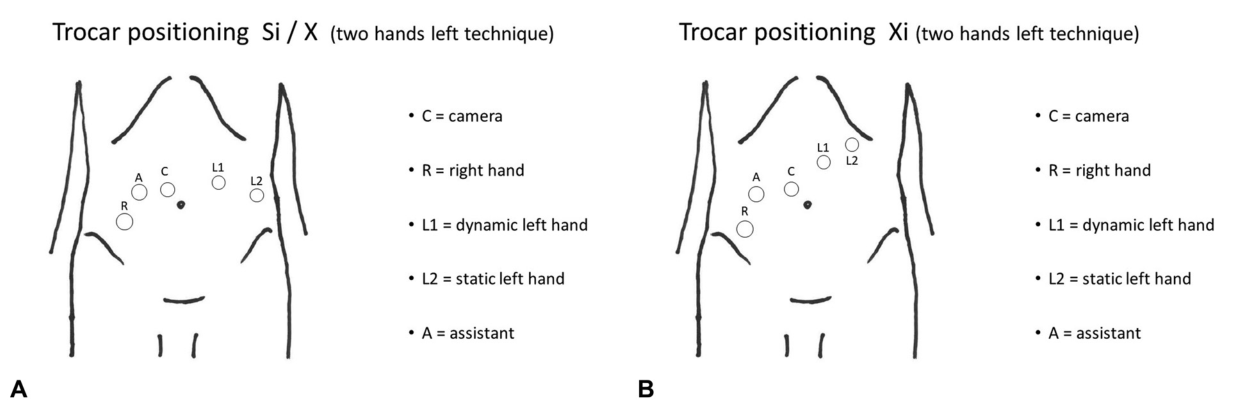

Fig. 1 (A) Schematic demonstrating trocar positioning using SI/X robotic platforms. (B) Schematic demonstrating trocar positioning using Xi platform.

dorsal side may be difficult to visualize. In that case, a more caudal placement of the camera trocar might be considered.

Although the robotic instruments are wristed at the tip, the instrument's otherwise straight design constrains the placement of the three instrument trocars. The second trocar will house the instrument used by the surgeon's dominant hand. For most surgeons, and also for left-handed surgeons, this is the right trocar. In general, it is recommended to place this trocar at the crossing point of the right midclavicular line and the line between the superior iliac spine and the midpoint of the abdomen. If this trocar is placed too lateral, access to the right side of the pelvis will be challenging. In turn, the right border of the mesorectum may not be reached. In older types of robotic systems with shorter instruments, the instruments may not reach the pelvic floor (i.e., distal mesorectum) if the trocars are placed too cranially.

The third and fourth robotic trocar placements differ based on the robotic system and operative goals. The third and fourth arms are used to generate traction and counter traction. One is static and substitutes the assistant surgeon in the laparoscopic setting. The other trocar is used by the surgeon's active left arm.

Two main types of placements can be distinguished: the two-hands right technique and the two-hands left technique. In the two-hands right technique (THR), the third arm is situated right of the camera, between the camera and the first instrument arm. In the two-hands left technique (THL), the third and fourth arms are placed left to the camera. In THR, the traction instrument is placed between the camera arm and the right hand. In the THL, the traction instrument is at the most lateral side. According to the European consensus on the standardization of robotic total mesorectal excision for rectal cancer, the preference is the two-hands right technique. In contrast, we favor the two-hands left technique.[8] Many early adopters of robotic platforms mainly use the two-hands left technique. We prefer THL, as in that technique, the static arm is absent from the visual field—it can support the sigmoid while remaining out of the line sight of the surgeon. In addition, there is more space for the assistant trocar. The following descriptions relate to the two hands left approach.

What Instruments to Use

The instruments used are largely a matter of personal choice. The following relates to our preference.

The camera arm: the camera arm holds the camera. A zero-degree or a 30-degree camera can be used. We use a 30-degree camera that can be switched between 30 degrees down or 30 degrees up. The upward position makes the ventral part beyond the pubic bone more visible and facilitates the most distal part of the dorsal (i.e., posterior) dissection of the mesorectum.

The right arm: scissors, cautery hook, or sealing devices can be used. Our preference is to dissect with scissors adhering to the principle of sharp dissection along embryological mesorectal planes. They can be used both as a unipolar cautery device and as scissors. The tip of the blades provides a precise cautery instrument.

The dynamic left arm: We use a bipolar cautery grasping instrument in the non-dominant hand as a forceps. The use of both unipolar and bipolar cautery instruments was a departure from our laparoscopic practice but has proved to be an improvement in achieving blood-less dissecting. Sealant devices do not permit adherence to fine embryological planes. However, where anatomical structures are deliberately crossed (i.e., partial mesorectal transection), sealing devices have technical advantages and may be time-sparing.

The static left arm: This arm partly takes over the task of the assistant surgeon. It is our preference to use the largest instrument available to deflect tissues.

The assistant trocar: This 12 mm trocar can be used to insert gauzes, suction devices, bowel grasper, or stapling devices. Sometimes, a second 5 mm trocar can be inserted.

Intra-abdominal Positioning

Exposure of the operative field is best achieved laparoscopically before docking the robot. The entrance to the pelvis and mesenteric vascular pedicles must be accessible at the origin of the inferior mesenteric artery (IMA). The left mesocolon must be accessible. Positioning the patient in a slight Trendelenburg and gentle right lateral tilt will, in most cases, be enough to gain access to mesenteric landmarks, including at the splenic flexure.

It is important to note this represents the final position of the patient, as the following docking, further changes are not possible without undocking the robot (or unless a motion table is in use). The omentum is pushed upward above the transverse colon and the small bowel is positioned in the upper right quadrant. To hold the small bowel, sometimes a gauze or surgical retraction sponges can be added.

Depending on the preference, the splenic flexure may or may not be taken down first. This topic will not be discussed here. After docking, lateral attachments (i.e., adhesions, or the reflection) of the sigmoid may be left or taken down. These attachments can be left as long as they contribute to the sigmoid traction. Sometimes, the lateral attachments hold a bulky sigmoid in a caudal position, thereby preventing access to the pelvis and mesorectum. After releasing the adhesions, the sigmoid will slide out of sight with gravity and exert a degree of traction on the rectum.

Entering the Mesorectal Plane

To enter the correct plane, the peritoneal entry point must be exposed. It is our preference to start on the right side of the rectosigmoid (often mislabeled as the medial approach). The camera's slight right lateral position helps to identify the peritoneal entry point. With the third, static lateral arm, the sigmoid is pulled ventrally toward the midline creating a pyramidal-shaped region on the right side of the rectosigmoid, between the latter on one side, and the aorta and promontory on the other. Irrespective of body mass index (BMI), traction in this manner always reveals a semi-circular indentation in the peritoneum, dorsal to the superior rectal artery. Importantly, this arch-like indentation is not apparent when the traction is exerted to the left. Traction to the left is a natural tendency of surgeons, as we have observed in our teaching practice.

After opening the peritoneum along the most ventral border of this indentation, air will enter into the areolar connective tissue of the posterior abdominal wall, and, almost immediately, the mesorectal plane will be apparent. In the first proximal part of the mesorectal dissection, this plane is situated close to the dorsal side of the superior rectal artery (SRA). Entrance to the plane should be cranial to the sacral promontory, where the sigmoid still has a long mesentery, and where the SRA can be readily displaced from the sacral promontory. This exposure ensures clear identification of the artery and adequate distancing from the hypogastric nerves. As a result, there is less risk to these nerves. A more distal entrance to the plane risks damage to the nerves.

The correct plane occurs at the boundary between the white extra-mesorectal loose connective tissue ("angel's hair") and the yellow-colored mesorectum. The essence of successful dissection is exerting traction in a manner such that this border is exposed. Dissection then proceeds along the border. All structures dorsal (i.e., posterior) to this border should remain dorsal.

Following this route underneath the mesorectum from right to left, close mesorectal dissection ensures that one remains ventral the left ureter. In regular, non-locally advanced cases, we do not routinely inspect for the ureter. To expose the ureter, it would be necessary to disturb the thin fascia covering the ureter and hypogastric plexus. In most cases, the ureter is encountered behind the thin and translucent connective tissue.

At this stage in the dissection, the left peritoneum can be opened ventral to the left ureter, either from the left or underneath the mesentery from the right.

Dissection of the Inferior Mesenteric Artery

Once the mesorectal fascia is identified, it is followed proximally (cranially) to the inferior mesenteric artery (IMA). To enable dissection at the root of the artery, the static third arm exerts traction, such that tension occurs along the axis of the IMA. In general, traction with the third arm is sufficient to achieve this. However, sometimes it is necessary to retract the sigmoid more cranially.

As the origin of the IMA is approached, some hypogastric plexus branches are encountered where they curl from the ventral and lateral sides of the aorta over the aortic bifurcation toward the sacral promontory. Due to traction, these branches may be raised 1 to 1.5 cm from the aorta. These structures can be considered the deepest, most dorsal border of dissection around the IMA root (►**Fig. 2**). Lymph nodes posterior to this border are rare—on occasion one will encounter lymph nodes adjacent to iliac arteries. Once the most superficial hypogastric nerves are encountered, the dissection proceeds ventrally to them around the IMA base toward the left side of the origin of the vessel. Adipose tissue

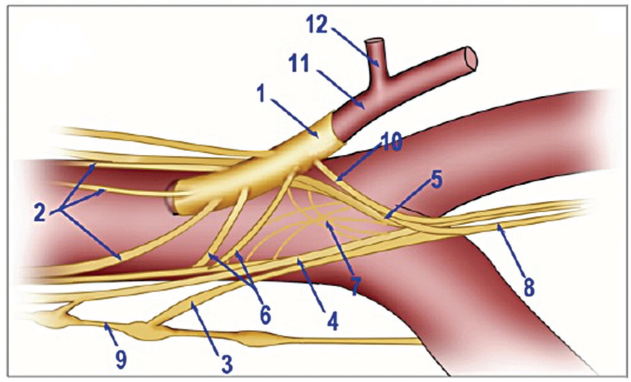

Fig. 2 Schematic illustration of nerves around the root of the IMA (Courtesy Yang et al[9]).

surrounding the artery contains the lymphatic nodes and vessels. A central lymphadenectomy is performed, dissecting the fat from the neurovascular sheet surrounding the adventitia of the IMA.[10,11] With the controlled and small movements of the robot, a sharp dissection can be done safely without endangering the vessels. In robotic surgery, vessels are threatened more by exerting too much traction, than by dissection.

After near circumferential dissection around the IMA, the dissection then progresses distally along the IMA. The left colic artery (LCA) will be encountered. In most cases, the inferior mesenteric vein lies just posterior to the LCA. The LCA normally has a dominant ascending branch, the ascending left colic artery (ALCA), from which branches may split in the left colon mesentery (►**Fig. 3**). The IMV runs parallel to the ALCA.

Medial to these vessels, a reflection of peritoneum occurs at the medial boundary of the left mesocolon, and proximal to the origin of the IMA. When followed laterally, this forms the surface of the underlying left mesocolon. When the left mesocolon is detached, the colon itself is encountered and can be detached.

We pay little attention to the level at which the IMA is ligated relative to its origin. That scientific debate is influenced by dogma, tradition, and lack of evidence. In most cases, we perform a low ligation of the IMA, distal to the LCA. Ligation of the IMV is performed at the level of the LCA. It is unnecessary to follow the IMV to the base of the pancreas. Some would advocate high (i.e., central) ligation of the IMA on the grounds that it may provide length for anastomosis, or on oncological grounds. Neither of these contentions has been proven.

Depending on the anatomy of the IMA, and trunks distal to the LCA, the superior rectal artery (SRA) will generally be ligated. Potential extra sigmoidal branches can be ligated as well. Of note, it is our practice to postpone ligation of the arteries until the end of the mesorectal dissection. This is because it is easier to exert traction on the mesorectum with an intact IMA.

The line of transection of the sigmoid mesentery follows the mesosigmoidal vasculature based on the observation that the fat of the rectosigmoid is oriented along the axis

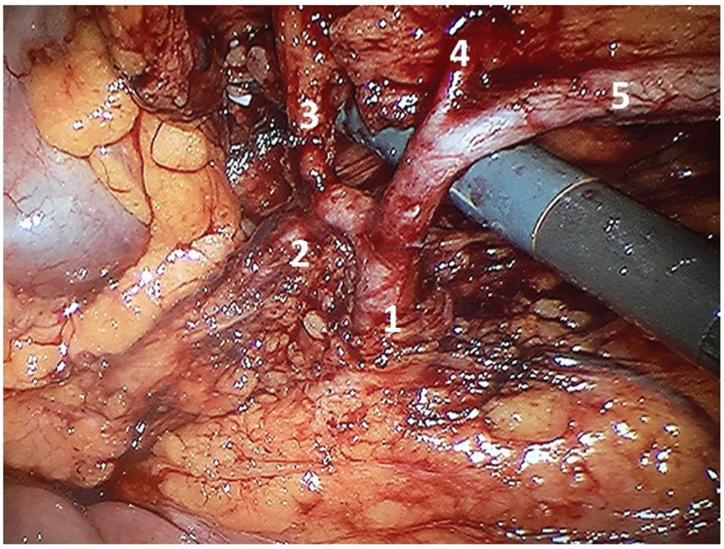

Fig. 3 Intraoperative photograph demonstrating central lymphadenectomy around the root of IMA.

of the vessels. It is relatively easy to dissect through bloodless watershed regions of the rectosigmoid where no more than the marginal vessels will be encountered. During this dissection, it must be remembered that vessels may bridge mesosigmoidal vessels and these bridging vessels require ligation.

From the IMA to the Pelvic Floor: the Holy Plane

After finding the correct plane, the easiest part of the dissection is usually the dorsal (i.e., posterior) part. During dissection, the connective tissue can be stretched out between the mesorectum (ventrally) and the layer covering the hypogastric nerves (dorsally). A border occurs between the yellow mesorectum and white connective tissue. The interface between both is the "holy plane" described by Heald. At the dorsal (i.e., posterior) limit of the connective tissue, a connective tissue boundary is apparent with the dorsal hypogastric nerve sheet underneath. Entering the hypogastric compartment endangers the nerves. In general, the hypogastric compartment contains variable amounts of fat. In patients with a lot of fat, a second, deeper border between the white connective tissue and the yellow fat of the hypogastric compartment is apparent. Dissecting along this boundary endangers the nerves and thus is too deep. Once the boundary between mesorectum and connective tissue is identified and followed, the dissection proceeds dorsally as far as possible. Little cautery has to be supplied, as no dorsal vessels cross this border. Gentle pressure often will be enough to dissect caudally. Tiny vessels should not be left on the mesorectum, as they are vessels in the loose connective tissue. In case of losing track in the mesorectal dissection, the solution can always be found at the dorsal side. Key in finding the proper planes is adequate traction and counter traction with the second and third arms.

Static traction is maintained with the left lateral instrument during the posterior dissection. At a proximal level, this may be achieved by grasping the rectum and retracting it anteriorly, the left lateral instrument can then be placed posterior to the mesorectum. It can then be used to gently force the mesorectum anteriorly. To hold the sigmoid out of the operative field, the left lateral arm is best introduced over the sigmoid to the right of the midline, and from there positioned behind the mesorectum. Gauzes or sponges can be used to minimize the trauma to tissues that are gently pushed aside.

O's and the A's during Dissection of the Mesentery

If the dissection is not at the innermost level of the connective tissue between the mesorectum and presacral fascia, warning signs appear. Holes emerge in the connective tissue (i.e., the "angel's hair") generating the "the O-sign" and signaling the dissection is too dorsal (i.e., posterior). Part of the connective tissue will remain on the mesorectum, and another part will remain on the presacral fascia. Between these, a gap will appear (►**Fig. 4**). Dissection in the middle of the connective tissue is intuitively judged by many as the correct route, but dissection here makes it more difficult to remain in the correct plane. Gentle dissection at the innermost level of the connective tissue (i.e., in the interface between it and the mesorectal surface) will generate a pyramidal shape (the "capital A" sign) (►**Fig. 5**). The apex of these shapes should be followed to stay in the plane, and thus dissect in the interface between the connective tissue and the posterior surface of the mesorectum.

From Dorsal (Posterior) to Lateral

During the dissection at the dorsal (i.e., posterior) side of the mesorectum, the lateral peritoneum may initially be left

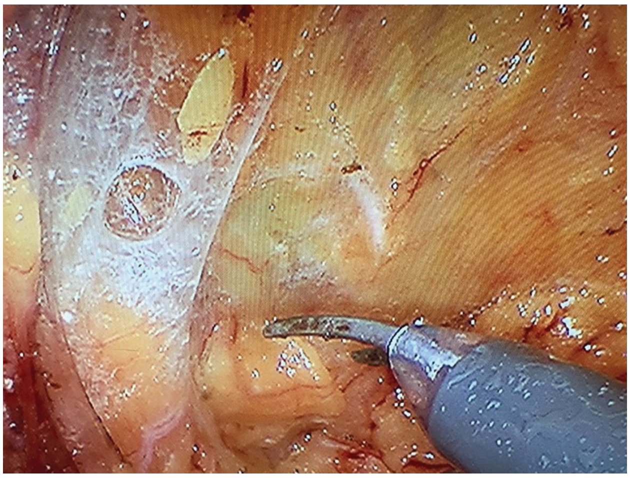

Fig. 4 Intraoperative photograph demonstrating the O-sign.

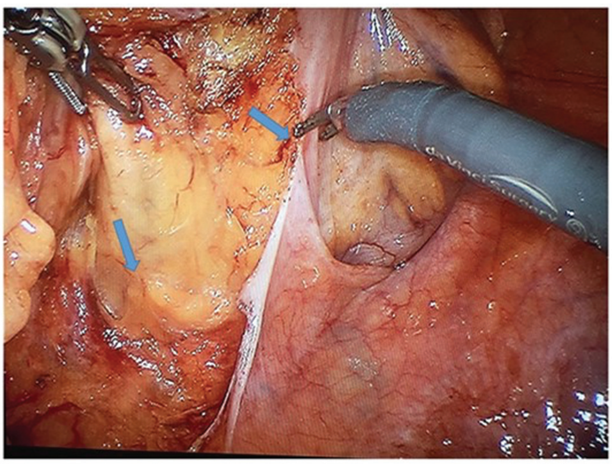

Fig. 5 Intraoperative photograph demonstrating the A-sign.

intact. This prevents peritoneal fluid or blood that is often pooling at the surface of the peritoneum, from entering the operative field. Once the posterior dissection is advanced, dissection may be continued at the sides of the mesorectum. The iliohypogastric nerves will be encountered in dissecting from the dorsal to lateral and then ventrally (i.e., anteriorly). These nerves run over the piriformis muscles beneath the muscle's fascia from dorsal to ventral (i.e., posterior to anterior) tangential to the surface of the mesorectum. Some of these, the parasympathetic splanchnic nerves or nervi erigentes, merge with the pelvic plexus. Others enter the mesorectum to innervate between 2 and 4 o'clock and 8 and 10 o'clock positions, to innervate the rectum. These latter nerves must be transected in total mesorectal excision. In case of a partial mesorectal excision, they may be left intact. After their division, the mesorectum will be freed at both sides up to the peritoneal reflection at 10 and 2 o'clock (i.e., anterolaterally on the left and right respectively).

Only the peritoneum now remains to be divided. The third arm now no longer pushes the rectum anteriorly, but instead is used to lift the rectum out of the pelvis into the abdomen. This places the peritoneal reflection on either side under stretch. The right part of the peritoneum (the right pararectal reflection) is opened first. Then the surgeon exposes the left side by retracting the rectum to the right using the static arm.

From Lateral to Ventral (Anterior)

At this point, the most challenging part of the dissection occurs: this involves the mesorectum between the 10 and 2 o'clock positions (i.e., on the left and right anterolaterally respectively). Here the middle rectal arteries (MRA) may enter the rectum. It is our institutional experience that, using the robotic platform, middle rectal arteries are often observed. The existence and relevance of these continue to be debated.[12] These arteries (together with nerves) course along the mesorectum from distally to proximally. After a distance of 1–4 cm, they enter the rectum. In most cases, electrocautery is sufficient to divide them; in a minority of cases, the MRA should be clipped.[13] After transecting these, one can advance more distally and ventrally. During this part of the dissection, the connective tissue thins and can be almost imperceptible. That is not to say that an interface is absent between the mesorectum (now posterior) and the non-mesenteric domain of the abdomen (now anterior). Nuances in the appearance of the mesorectal fat may guide the surgeon. One has to be cautious not to dissect too lateral in this region, especially in men, where the nervi erigentes may be damaged. During dissection from MRA in the direction of the seminal vesicles, a too lateral dissection is indicated by bleeding of the vessels in the ventrolateral neurovascular bundle that supplies the bladder, prostate, and penis.[14]

Ventral (Anterior) Dissection

In the penultimate stage of dissection, the ventral (anterior) peritoneal reflection is opened. Some surgeons elect to divide this early, to facilitate lateral and anterolateral dissection. The correct plane of dissection lies between the mesorectum (posteriorly) and the non-mesorectal domain of the abdomen (anteriorly). Identification of this plane remains controversial. Controversies persist related to the existence and development of Denonvilliers fascia (DVF). Differences occur between men and women and the line of dissection may be difficult to identify. Notwithstanding controversies, oncologic principles must prevail. In anterior tumors with a challenged circumferential margin, the dissection must be in front of DVF. However, in most patients, dissection should be performed behind DVF (i.e., in the interface between it and the underlying mesorectum) to preserve nerves located in front of DVF. Dissecting from lateral to ventral, one should aim to enter the interface behind DVF in continuity with the mesorectal plane in which one was dissecting at proximal levels. It will seem that the surface mesothelial lining appears to have been lost at this level.[15,16] In direct ventral dissection, DVF often has to be transected to enter the plane behind DVF. The first results of a recent Chinese randomized trial confirm better functional results after preserving DVF.[17]

Dissection of the Distal Mesorectum in TME

The advantages of robot-assisted surgery are greatest in distal mesorectal dissection. In laparoscopy, it may be very difficult to reach the distal mesorectum, especially in obese men with a lengthy but narrow pelvis. These challenges led to the emergence of techniques like transanal total mesorectal excision (TaTME). However, robot-assisted laparoscopy has overcome the challenges of conventional laparoscopy. Dissection of the most distal part of the mesorectum, which abuts the pelvic floor musculature, is best commenced posteriorly. Distally, the dorsal mesorectum has a midline cleft on either side of which the mesorectum bulges to generate an appearance similar to "buttocks." The cleft extends into a fibrous structure, the anococcygeal raphe or ligament. This raphe is the continuation of the presacral fascia and the insertion of several components of the levator ani and the external sphincter complex. In most cases, it is not sharply delineated.

To mobilize the rectum, the anorectal raphe must be transected. This region is a junction between the mesenteric and non-mesenteric domains of the abdomen and as such, mobilization of the rectum requires division through this (i.e., disrupting anatomy). The dorsal (posterior midline) position of the anococcygeal ligament means that the mesorectum can be separated from the underlying pelvic floor (i.e., the *levator ani* musculature) on either side, before the division of the ligament. At this level, the mesorectum has an anatomical limit (i.e., this is its distal extremity). At the anorectal junction, the rectum is not surrounded by mesorectum. The levator ani muscles are covered by a thin fascia. By exerting traction on the rectum, this fascia (between the puborectal muscle and the mesorectum) comes under stretch. By gentle traction or sharp dissection, this fascia can be separated from the mesorectum medially. If separation of the fascia and mesorectum is continued distally to the pelvic floor, the surgeon enters the intersphincteric space. Neurovascular bundles run over the levator fascia at 10 and 2 o'clock positions, to reach the rectum, at which point they turn and follow the axis of the rectum proximally. These include the inferior rectal arteries, which are branches from the internal pudendal arteries. If possible, in low anterior resection, they should be spared. Especially in robotic surgery, during abdominoperineal resection (APR), the dissection can be continued distally to the rectum.

Abdominal Perineal Resection

In the case of an intersphincteric APR, the intersphincteric plane can be entered following the thin fascia covering the levator muscles as described above. In a non-intersphincteric APR, the levator muscles lateral of the rectal wall can be split along the orientation of the muscle fibers. If this is continued, the ischiorectal fossa is entered and subcutaneous adipose tissue becomes apparent. Although dissection to skin level is feasible, we generally stop the dissection from above down. This is because landmarks are no longer apparent and the surgeon can lose their anatomical orientation relatively easily. The perineal (below-up) phase can then be commenced. Given the extent of the above-down dissection described above, the perineal dissection is relatively limited. This is thought to be beneficial in limiting infections after. In the case of an extended or cylindrical APR the mesorectum is not separated from the levator muscles.

Dangers and Pitfalls during Robotic Rectal Surgery

There are potential dangers in robot-assisted colorectal surgery that relate to technique. One challenge includes a ***lack of haptic feedback***. Lack of haptic feedback means the handling of out of sight instruments becomes more dangerous than during conventional laparoscopic surgery. This applies in particular at the start of the learning curve. At first, it is difficult to appreciate the forces exerted by robotic instruments. As a result, structures may be torn by excessive traction. Experienced robotic surgeons may develop surrogate haptic feedback through visual cues. However, this does not apply for out of sight instruments. Structures at risk include bowel, inferior mesenteric vein and artery. Moving instruments out of sight increases this risk. Without noticing it, intra- or extraperitoneal tissues and organs can be damaged. Mishaps may also occur under direct vision. Lack of tactile feedback means that, even with visual feedback, there is a risk of small bowel tears or enterotomies during manipulation of the bowel.

There are often assistant-related factors to address. During the introduction of the assistant's instruments, the small bowel may be injured. This may be noticed less in robotic surgery than in laparoscopy as the introduction is not always visualized and the assistant is at a distance from the primary surgeon, who then may not see how the instrument is being inserted. These challenges demand clear and explicit communication of instructions between surgeon and assistant. Additional problems may arise in relation to the pivot points of trocars (i.e., the fulcrum around which the remote centers swivel). Undue traction at these points may lead to hematomas and subcutaneous emphysema.

Challenging Mesentery in Robotic TME

The learning curve for robotic surgery may be shorter for laparoscopic than for open surgeons. Laparoscopic surgery already has provided insights in anatomy and knowledge regarding traction that can readily be transferred to robot-assisted laparoscopic surgery. The apparently vast level of anatomical details may initially seem overwhelming, as the tiniest of structures may be misinterpreted as nerves or vessels of significance. After overcoming this initial challenge, the surgeon will not face many difficulties during the dissection, so long as he/she adheres to embryological planes. Respect for multiple regions of fascia will prevent inadvertent injuries of vessels, nerves, and other organs such as the ureters. Blood loss will be minimal and postoperative functional results correspondingly good.

Difficulties arise with inadequate traction, inadequate exposition, and lack of situational awareness or preparation. These often reflect a lack of knowledge and experience. However, certain anatomical properties will create challenges for all surgeons. In morbidly obese patients and after neoadjuvant treatment, finding the correct compartments may be difficult. In the former, the presacral fascia, lateral and ventral compartments usually contain more fat, with the result that it may be more difficult to recognize the layer of connecting tissue between compartments. Neoadjuvant treatment may result in edema and hyperemia of the tissues.

Significant problems can arise from anatomical abnormalities due to the underlying disease (i.e., when the disease process transgresses embryological compartments and planes). Extramesorectal dissection may be required to circumvent locally advanced/T4 tumors, abscesses, adhesions, or other forms of locally advanced pathology. The robotic approach offers advantages in these contexts because of enhanced visualization and wristed instrumentation. The assistant is then free to introduce additional instruments. In case of bleeding, for example, in the case of heavy bleeding from presacral veins, the third arm can provide a stable, instrument to maintain the pressure and thus tamponade the bleeding. The low conversion rates in many studies on robotic rectal cancer surgery point to enhanced control in challenging circumstances, compared with that afforded by laparoscopy.[18–20]

Conclusion

Robot-assisted surgery offers many advantages during the dissection of the mesentery of the rectum. Currently, it provides a high-quality system and tools by which to recognize meticulous anatomic detail and use this to generate the correct dissection plane. These advantages represent a considerable added value when it comes to the dissection of the mesorectum.

Conflict of Interest

Rogier Crolla and Esther Consten are both proctors for Intuitive.

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