Minimally Invasive Low Anterior Resection

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Matthew Albert and Marc Dakermandji

Introduction

Laparoscopic low anterior resection (LAR) is a technically challenging operation that has two main components: complete mobilization of the hindgut followed by precise rectal dissection with precise division of the mid or distal rectum. Obtaining a completely intact mesorectal envelope (i.e., total mesorectal excision, TME) is of critical oncologic importance. As such, maintaining the rectal dissection within the proper anatomic planes has direct influence on local recurrence rates. A successful TME involves obtaining a grossly intact mesorectal envelope (grade 3), a negative circumferential resection margin (CRM ≥2 mm) and a negative distal resection margin (DRM) while providing sphincter preservation with adequate functional outcomes [1].

High ligation of the inferior mesenteric artery (IMA) should be performed to include routes of primary lymphatic drainage in addition to the contiguous mesorectum. Division of the IMA proximal to the ascending left colic artery as opposed to distal ligation remains an unresolved technical variation with no clear evidence supporting standardization. Surgeons also debate the necessity of routine splenic flexure mobilization, which we believe is required to provide a tension-free low pelvic anastomosis with adequate distal blood supply for surgery of the left colon and rectum [2]. While applying traditional oncologic principles for left-sided colonic cancer surgery, one must consider patient body habitus, disease status, comorbidities, as well as functional outcomes following LAR. The sigmoid colon is commonly a poor conduit, especially when narrowed and thickened with diverticular disease. Furthermore, adequate colonic mobilization to permit reconstruction with a colonic J pouch should be strongly considered and may necessitate more length. This requires complete splenic flexure mobilization to the middle colic trunk with high ligation of the IMA below the takeoff of the left colic artery; and division of the inferior mesenteric vein (IMV) at the base of the pancreas to provide maximal colonic length.

However, critics to this approach often cite routine splenic flexure mobilization as usually unnecessary and potentially detrimental to distal colonic perfusion. In our experience, for the most reproducible and standardized resection, we recommend routine splenic flexure mobilization for all patients via medial-to-lateral approach begin-

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M. Albert (✉) · M. Dakermandji
Department of Colorectal Surgery, Center for Colon & Rectal Surgery, Florida Hospital, Orlando, FL, USA
e-mail: matthew.albert.md@adventhealth.com; marc.dakermandji@flhosp.org

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ning at the mesoduodenal ligament. This can be achieved in multiport or reduced-port fashion with safety, efficacy, and reproducibility.

Patient Positioning

Prior to placing the patient on the bed, the controls should be interrogated to confirm proper function. The patient is placed in the modified Lloyd-Davies position using Allen stirrups, preferably on any commercially available nonslip pads. An additional strap is placed across the chest to secure the patient from slipping during steep bed movements. It is critical that the legs are abducted and placed parallel with the torso in order to prevent working collisions while operating through the lower abdominal ports. The arms are padded and tucked, gel rolls or specialized shoulder padding is placed, and a Bair Hugger (3M, St Paul, MN) or other warming device is utilized. The patient must be placed low enough on the bed to access the anal canal for stapler placement, anticipating some degree of patient migration superiorly.

Port Placement

For laparoscopic low anterior resection, ports are most commonly utilized at the umbilicus, the suprapubic position (for easy extension to a Pfannenstiel incision), the right lower quadrant, and the right upper quadrant (Fig. 22.1a). Port placement in these positions will allow easy access to the apex of the splenic flexure with adequate length while still allowing access to the left lower quadrant for mobilization of the sigmoid colon and subsequently the pelvis. Flexibility with port placement is necessary when the splenic

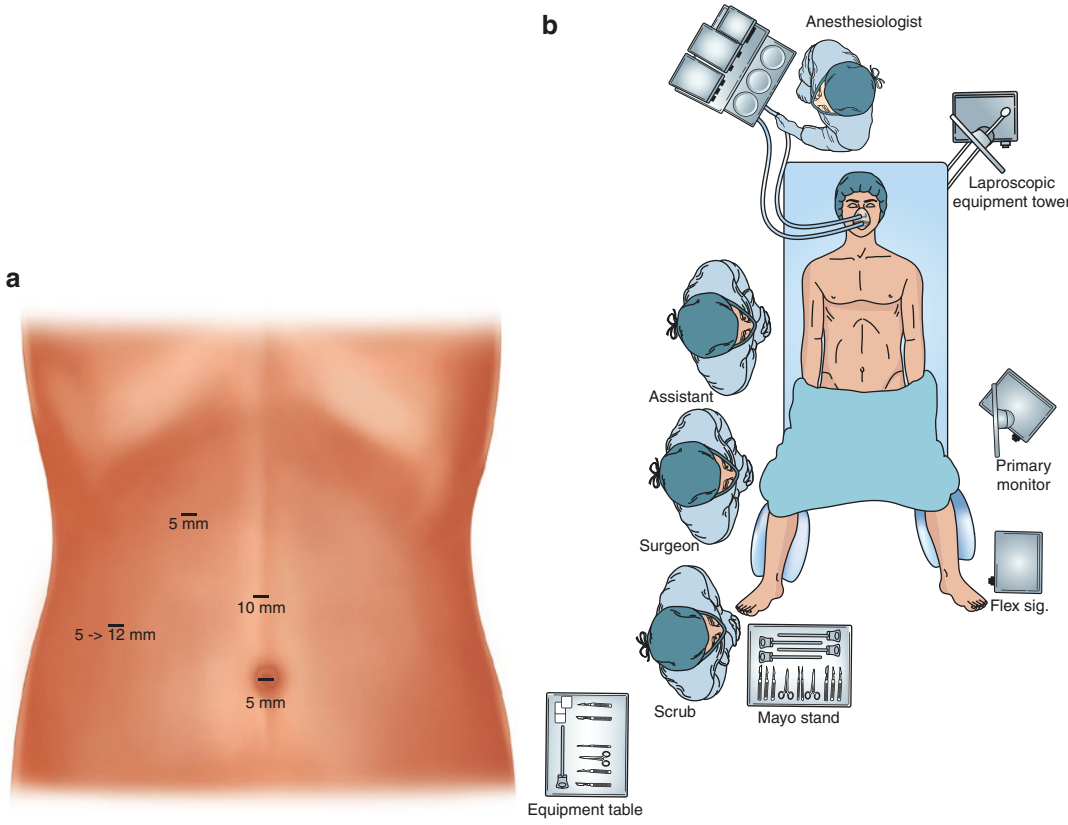

Fig. 22.1 (**a**) Trocar/port positioning for minimally invasive low anterior resection (LAR). (**b**) Patient and surgeon positioning for minimally invasive LAR

flexure is mobilized in preparation for left colon resection accompanied by high or low pelvic anastomosis. As rectal dissection begins, the addition of a left lower quadrant port is helpful for the assistant surgeon.

The benefits of utilizing a Pfannenstiel port placement are multiple, as both stapling of the rectosigmoid colon and specimen extraction can be accomplished at this location. Additionally, cosmesis is optimal here, and postoperative incisional hernia risk is extremely low. Interrogation of the anastomosis through the incision, if there is a positive leak test, is also easily performed with occasional minimal enlargement of the incision. Port placement in the right lower quadrant can be planned accordingly if a diverting stoma is anticipated, especially in patients who receive neoadjuvant chemoradiotherapy. In thin patients, specimen extraction can also be performed through the ileostomy site, and extraction can be facilitated by a wound protector. In our experience, enlarging the fascial opening to facilitate extraction is better to avoid specimen fracture or mesenteric avulsion.

Both the operating surgeon and assistant stand side by side on the right side of the table (Fig. 22.1b). The dissection is carried out by the two surgeons performing tasks from their respective vantage points and alternating between the role of assistant and camera operator. The laparoscopic monitors are positioned opposite the operating surgeon over the left shoulder of the patient and can be easily transferred down toward the left leg as the dissection moves near the pelvis. An angled 30 ° or 45 ° camera is strongly recommended.

Lateral, Medial, Inferior, and Supramesocolic Approaches

As in open colon surgery, early attempts at laparoscopic colonic surgery were generally performed with the lateral-to-medial approach initiated anywhere along the mesosigmoid recess, sigmoid colon, or descending colon. Although it may be the most intuitive approach, the lateral approach is challenging and requires the surgeon to continuously look over the colon. As such, the splenic flexure can be difficult to take down especially when it is quite cephalad, and critical retroperitoneal structures are not identified until later in the dissection.

In contrast, the medial approach to left colon mobilization begins along the midline at the root of the mesocolic attachments and is traditionally started with a peritoneal incision over the mesosigmoid colon beneath the trunk of the IMA and toward the sacral promontory. In our experience, the left mesocolic origin is more easily targeted at the ligament of Treitz (LOT) just below the IMV, which has been referred to as the inferior or sub IMV approach. Either location allows easy access to the retroperitoneum, early high ligation of the major colonic vascular pedicles, and prompt identification of the left ureter and gonadal vessels while keeping the colon suspended by its lateral attachments. The inferior approach has become increasingly common for the proponents of routine splenic flexure mobilization. Notably, the constancy of the location of the IMV as it courses by the ligament of Treitz enables immediate and clear identification of the initial point of dissection (Fig. 22.2). Division of the IMV at the base of the pancreas permits maximal colonic length. This approach permits division of the base of the transverse mesocolon at its origin along the pancreas, entry into the lesser sac, and division of the splenorenal ligaments posteriorly to assure complete mobilization of the splenic flexure.

In the supramesocolic approach, the dissection begins with entry into the lesser sac adjacent

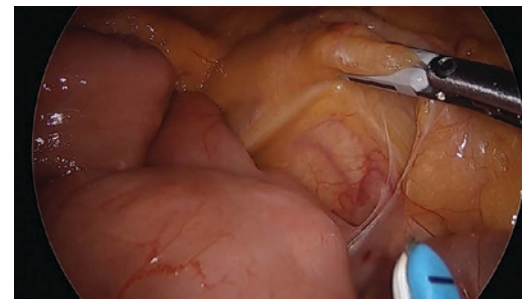

Fig. 22.2 Intraoperative image showing identification of the inferior mesenteric vein near the ligament of Treitz

to the gastroepiploic arcade and exit from the omentum attached to the colon or performing the dissection along the transverse colon wall, which will leave the omentum on the stomach. Dividing the gastrocolic and splenocolic ligaments and joining the lateral and retroperitoneal dissection will release the colon up to the middle colic pedicle. In practice, routine splenic flexure mobilization may utilize all three approaches. Performing splenic flexure mobilization in this stepwise, methodical approach allows adequate oncologic resection and identification of all critical anatomy, thus minimizing the occurrence of complications.

Operative Steps

Medial-to-Lateral Dissection

A video of the entire procedure can be seen in Video 22.1. After establishing pneumoperitoneum through an umbilical 12-mm port, the liver, small bowel, and colon and rectum are inspected. Adequate bed positioning (right side down and moderate Trendelenburg position) is critical to displace the entire small bowel contents to the right side of the abdomen. With the IMV grasped and placed on tension toward the abdominal wall, a transverse incision is created at the base of the mesentery from just below the IMV following the contour of the left colic artery as it joins the IMA (Fig. 22.3). The correct plane between the mesocolon and retroperitoneum is easily identified, and medial-to-lateral dissection is performed on top of Gerota's and Toldt's fascias up to the inferior edge of the pancreas. It is important to dissect as far lateral as possible under the colon to the abdominal sidewall and underneath the splenic flexure (Fig. 22.4a, b).

Following the dissection superiorly along Toldt's fascia will lead the dissection posteriorly to the pancreas, quickly exposing the splenic vein first and then the splenic artery. At this point, the posterior dissection should cease, and the dissection should proceed on the anterior surface of the

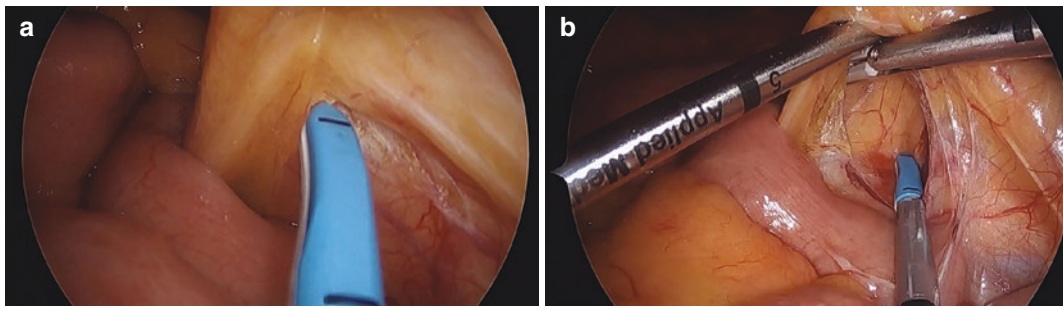

Fig. 22.3 Intraoperative image showing (**a**) incision of the mesentery directly posterior to the inferior mesenteric vein (IMV). (**b**) The space posterior to the IMV is gradually enlarged by blunt dissection with laparoscopic instruments

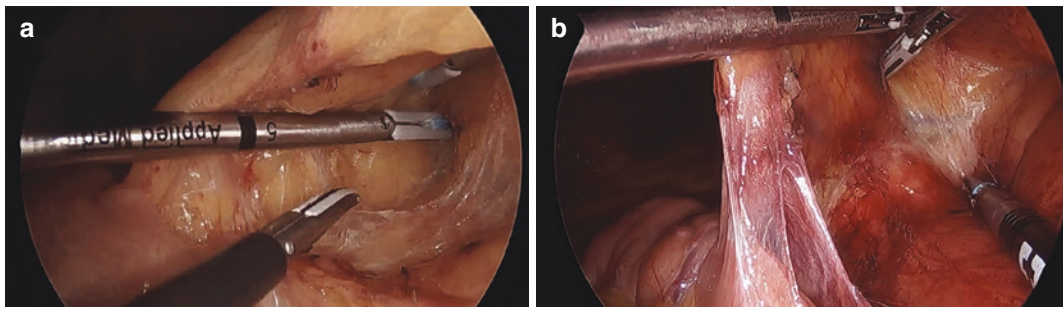

Fig. 22.4 Intraoperative images (**a**, **b**) show the medial-to-lateral dissection as it reaches the lateral abdominal wall

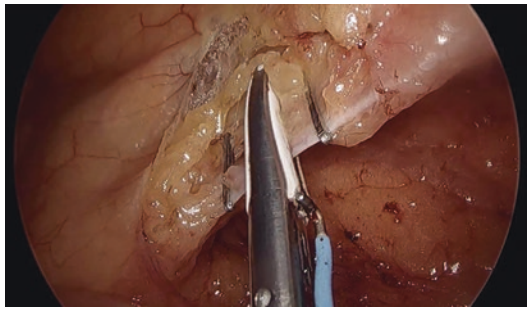

Fig. 22.5 Intraoperative image showing clipping and ligation of the inferior mesenteric vein

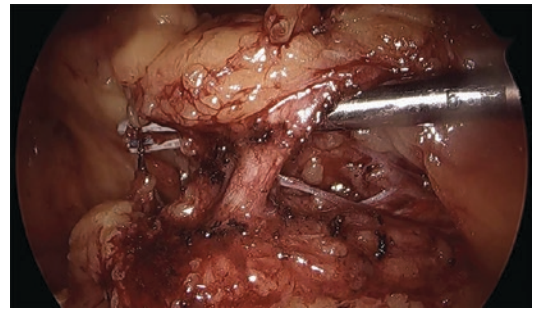

Fig. 22.6 Intraoperative image showing isolation of the inferior mesenteric artery

pancreas, making an incision at the inferior border of the pancreas at the root of the transverse mesocolon. The mesocolon is slowly divided and the lesser sac can be entered. Following lesser sac entry, the remainder of the transverse colon mesentery is divided laterally toward the tail of the pancreas.

The IMV is isolated at the base of the pancreas below the insertion of the left colic vein and is divided between clips or with an energy device (Fig. 22.5). Rarely, a meandering mesenteric artery (of Moskowitz) may run through the triangle formed by the IMV, left colic artery, and the inferior edge of the pancreas. Knowledge and preservation of this anatomic variant are critical to maintaining perfusion of the left colon.

The initial peritoneal incision is continued inferiorly over the origin of the IMA, along the origin of the mesosigmoid and mesorectum toward the pelvic inlet. From the medial-to-lateral approach, the mesocolon is mobilized off the retroperitoneum under the superior rectal artery and vein, identifying the hypogastric nerves, left ureter, and the left gonadal vessels while working toward the lateral sidewall. At this point, the instrument in the right hand can be placed below and behind the superior rectal artery, exposing the origin of the IMA proximal to the left colic branch for division with an energy device and clips (Fig. 22.6). Just prior to skeletonization of the IMA, the sigmoidal branches from the right and left splanchnic nerves are divided while preserving the lumbar splanchnic nerves. The left colic artery is also divided at this time to facilitate extraction.

The Lateral Component

With the patient in the right side down and moderate Trendelenburg position, the sigmoid colon is retracted medially using an atraumatic bowel grasper in the left hand and the peritoneal attachments in the mesosigmoid fossa can be incised over the "bruise" created from the previous retroperitoneal dissection, joining the medial and lateral dissection (Fig. 22.7a). With an instrument under the mesocolon to provide exposure while avoiding grasping the colon, the white line of Toldt can be incised along the lateral edge of the descending colon up to and occasionally cephalad to the splenic flexure (Fig. 22.7b, c). When the initial medial dissection is performed adequately and the pancreas is dropped posteriorly, the lateral dissection can be extended easily onto the transverse colon.

Supramesocolic Approach

With the patient in the right side down and moderate reverse Trendelenburg position, a third instrument (suprapubic port) is used to improve triangulation during omental dissection to retract the transverse colon toward the pelvis. With the operating surgeon facing cephalad, the greater omentum is retracted over the transverse mesocolon and grasped near the attachments of epiploic fat and transverse mesocolon. With an energy device in the right hand, the omentum is divided and the lesser sac is entered. Our preference is to divide the omentum and enter the lesser sac just

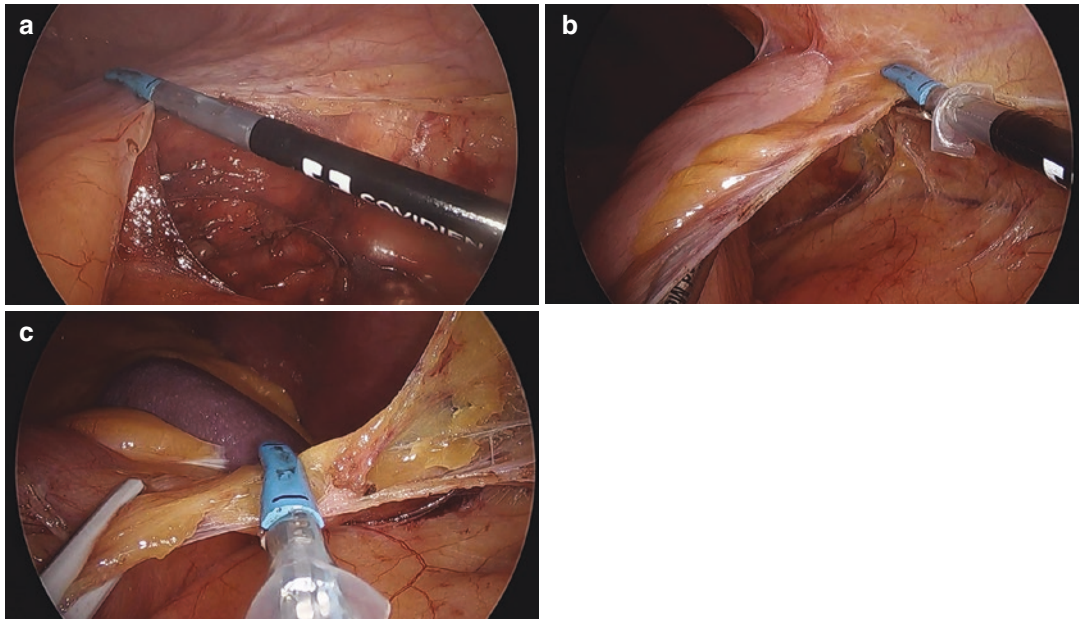

Fig. 22.7 Intraoperative images show (**a**) dissection with the lateral approach meets the medial dissection. (**b**, **c**) The white line of Toldt is incised cephalad to the level of the spleen

along the gastroepiploic arcade rather than along the transverse colon which is more difficult. Once lesser sac entry is established, the assistant instrument can be placed inside the lesser sac underneath the omentum and retracted caudad to protect the transverse mesocolon from accidental injury. Following division of the omentum to communicate with the lateral plane previously dissected, the mesocolic plane at the inferior edge of the pancreas is identified and incised, leading to communication with the previously established retroperitoneal plane. The final splenocolic ligaments are divided, completely releasing the splenic flexure up to the middle colic pedicle. Care must be taken when performing this approach so that the attachments to the omentum at the angle of the splenic flexure are not tethering the descending colon and hindering its mobilization into the pelvis.

Rectal Mobilization and Total Mesorectal Excision

Primary mobilization of the left mesocolon with early division of the appropriate vasculature permits safe access and exposure for initiation of the rectal dissection. At this point, critical structures including the left ureter, gonadal vessels, and superior hypogastric plexus have already been identified to guide the surgeon into the correct mesorectal planes.

The operating room setup is identical to splenic flexure mobilization but requires the main operating surgeon to use the two lateral ports while facing toward the pelvis. Cephalad and anterior traction is provided by the assistant through the suprapubic port. A camera operator stands on the left side of the abdomen. An additional left lower and/or left upper quadrant 5-mm port is required for the assistant surgeon to retract the colon out of the pelvis. An experienced assistant can provide similar retraction through the suprapubic port while standing at the patient's right hip adjacent to the operating surgeon.

The posterior dissection begins with entry into the presacral space. This can be achieved by following the mesenteric cut edge caudally and parallel to the superior rectal artery. This should be preceded by having the rectosigmoid mesocolon fully dissected off the inter-sigmoid fossa and sacral promontory and confirming the loca-

tion of the left ureter laterally. The shiny visceral package of the fascia propria enveloping the mesorectum must be identified. This will allow entry into the bloodless plane between the fascia propria and presacral fascia down to the distal resection site. The innermost dissectible plane can be developed by maintaining dissection on the "yellow side of the white." An important landmark is the area where Waldeyer's fascia begins to transition anteriorly to join with the fascia propria of the rectum. One must be aware of this transition and incise Waldeyer's fascia at this location to avoid dissection deep through the presacral fascia and into the sacrum.

Of important note, pelvic exposure can be facilitated by locking the assistant's grasper (suprapubic trocar) onto the bowel just proximal to the rectosigmoid junction. This can be placed in a position which allows good clearance of the pelvic inlet from redundant bowel and mesentery while avoiding repositioning and obstructing the primary surgeon's instruments. This provides the primary surgeon with the ability to easily redirect tension to expose the right, left, and posterior working spaces with ease, often independent of the skill of the assistant.

The posterior dissection can also be facilitated by delaying the anterior and lateral rectal dissection until the distal-most extent of the posterior dissection is reached or until progress ceases. Using gauze in the main surgeon's retracting grasper can be an effective source of countertraction to better tent the fibrous tissue. This is particularly helpful when space is limited in the deeper pelvis and there is considerable fatty bulk or tissue elasticity of the mesorectum such that a grasper alone fails to achieve leverage and traction. Additionally, a laparoscopic fan retractor can be placed through the suprapubic port for both posterior retraction as well as anterior retraction in the peritoneal reflection.

The lateral dissection starts from the right side (Fig. 22.8a, b), carefully identifying and sweeping down the hypogastric nerves, which can be tented upward to the mesorectal fascia with traction. These nerves are particularly vulnerable when joining the lateral dissection with the posterior dissection. The lateral ligaments are placed under tension by drawing the rectum to the either side of the pelvis and are dissected carefully to preserve the nerve trunks that travel distally.

The anterior dissection is performed after scoring the peritoneum on either side of the rectum down the lateral rectal sulci and then continuing along the anterior surface and opening up the peritoneal reflection in the pouch of Douglas. This is continued by dissection in the cul-de-sac exposing Denonvilliers' fascia and protecting the seminal vesicles or vaginal wall separating these structures from the rectum. Denonvilliers' fascia is a key landmark, as its lateral edge is just medial to the nerves. At this location in the pelvis, the rectum acutely angulates changing course in a more horizontal fashion. Continued dissection of the extraperitoneal rectum requires constant traction, frequent changes in exposure, and continued circumferential dissection to elevate the rectum from the pelvis. Challenges in laparoscopic dissection of the distal mesorectum with variable outcomes in CRM positivity have been the impetus for evolving techniques of robotic and transanal TME (taTME) to overcome the hurdles of surgical exposure and precision.

Dynamic retraction and exposure are used to facilitate dissection of the distal mesorectum off the endopelvic fascia overlying the pelvic floor. In the posterior midline, convergence of fascial fibers forms a midline raphe which requires complete division (Fig. 22.8c). In patients with upper rectal tumors, division of the rectum 5 cm distal to the tumor is recommended (partial mesorectal excision). This approach maintains oncological principles while sparing rectum with resulting improved function compared to lower anastomoses. However, precise division of the mesorectum at its widest point is ergonomically challenging. Despite proximal transection of the rectum, complete mobilization to the pelvic floor is still necessary to allow enough mobility for mesorectal division.

Once the appropriate distal margin is identified, an endoscopic stapler is used to transect the rectum. Division of the rectum should be performed directly perpendicular to the wall to minimize the number of intersecting staple lines. Optimally, ≤ 2 firings should be used, as >2 staple lines have

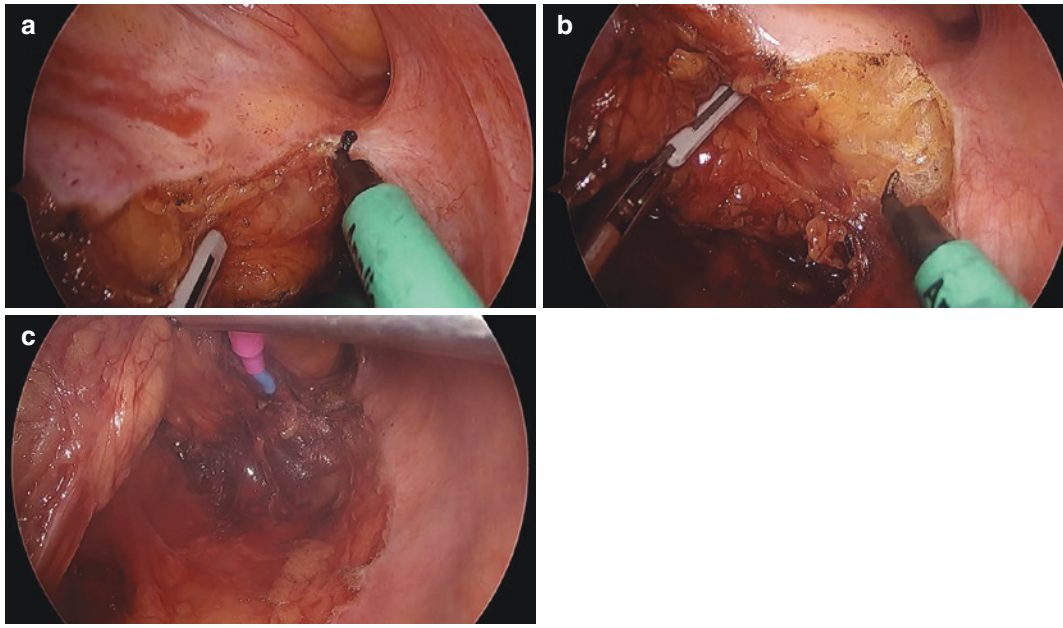

Fig. 22.8 Intraoperative images show (**a**, **b**) right lateral pelvic dissection and (**c**) deep posterior presacral rectal dissection

demonstrated increased rates of anastomotic leak. Upsizing the suprapubic or right lower quadrant port to 12 mm is necessary to introduce a traditional endoscopic linear stapler. Stapling from the right lower quadrant enables a more traditional horizontal division of the rectum. However, limitations in stapler reticulation as well as variations in port position can provide challenges. For example, inadvertent inclusion of left lateral pelvic sidewall structures at the tip of the stapler should be avoided. In addition, port site hernias through 12-mm trocar sites can occur and therefore require closure. Alternatively, introduction of the stapler through the suprapubic port can be accomplished providing a vertical transection of the rectum. With this approach, angulation of the stapler is ergonomically challenging and not possible in every pelvis. The colon is exteriorized through the Pfannenstiel incision and the IMA pedicle is identified. If it was not performed intracorporeally, the left ascending branch is divided from the IMA. The remaining mesocolon and marginal vessel are then divided up to the distal descending colon identifying the proximal colonic margin.

It is our practice to evaluate the proximal colonic transection line for adequate perfusion prior to performing an anastomosis for all left colon resections [3, 4]. The proximal transection site is chosen after intravenous injection of 2–3 ml of indocyanine green and visualization of the bowel to confirm an intact marginal vessel and mural perfusion. This perfusion assessment is used in conjunction with traditional means of assessing of conduit viability such as marginal vessel or staple line bleeding.

Reconstruction

Different methods of rectal reconstruction have been proposed. Although an end-to-end anastomosis is most simple, both colonic J pouch and end-to-side anastomosis have demonstrated superior functional outcomes. A balanced approached must be considered when striving to maximize postoperative function, as technical feasibility will frequently be the determining factor particularly when the narrow pelvis or bulky conduit may only permit an end-to-end anastomosis. A 6- to 8-cm colonic J pouch is constructed with an incision along the antimesenteric border of the colon and a single firing of a linear

stapler. The anvil is then secured into the colotomy with a purse-string suture. Otherwise an end-to-side anastomosis can be fashioned by inserting the anvil portion of the stapler with its sharp spike attachment into a colotomy, which is brought out of the antimesenteric colon wall about 5 cm proximal to the blind end. The distal colon wall is then divided with a linear stapler.

The circular stapler is brought through the staple line of the rectal stump, and the anastomosis is completed with a circular stapler. Orientation of the colonic conduit should be confirmed by ensuring a straight path of the mesenteric cut edge from distal to proximal. Care must be taken to reduce herniated small bowel underneath the left mesocolon. Routine closure of the mesenteric defect to the retroperitoneum is not routinely performed as small bowel obstruction is rare.

Routine use of pelvic drains has not demonstrated reduction of pelvic sepsis and is therefore not routinely performed. Proximal fecal diversion is performed at the discretion of the surgeon, however, should be strongly considered in patients who received preoperative radiotherapy. Postoperative care includes early mobilization, resumption of solid food, and minimization of opioid pain medications consistent with Enhanced Recovery after Surgery protocols (ERAS).

Tips and Tricks

- Optimal exposure of the left mesocolon is ensured by appropriate patient positioning at the beginning of the operation. Correct positioning will also serve to prevent the patient from slipping during extreme steep table positions.
- Caution must be taken when dissecting below the inferior mesenteric vein after dividing the mesoduodenal ligament to avoid going into the retroperitoneum where the left gonadal vein, ureter, and left renal vein are exposed and are vulnerable to injury. Even in obese patients, the mesocolon in this area is much thinner compared to other major vascular pedicles. In thin patients, lymphatic vessels that run parallel to the aorta are frequently present.
- Rarely, a meandering mesenteric artery may be encountered, and one must be familiar with this anatomic variant to avoid injury and to minimize ischemia to the left colon.
- To avoid injury to the pancreas, it is critical to identify Toldt's fascia posterior to the pancreas, since this is the stopping point for the inferior dissection. The dissection is then continued at the level of the pancreas to divide the origin of the transverse colon and to enter the lesser sac.
- Incising the transverse mesocolon from the base of the pancreas can be challenging for surgeons early in their learning curve. The lesser sac can often be more easily entered along the distal pancreas where gastropancreatic attachments are less common. Even if the lesser sac is not completely entered, it will facilitate identification of the correct plane once the lesser sac is entered through the gastrocolic ligament and the "bruise" along the pancreas is visualized.

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