Total Mesorectal Excision/Low Anterior Resection (Open, Laparoscopic)

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Kyle G. Cologne, Anthony J. Senagore, and Andreas M. Kaiser

Indications

- Rectal cancer
- Large rectal polyps not amenable to less invasive approach
- Rectal carcinoid with unfavorable size or pathological features

The extent and approach (open versus minimally invasive) chosen for the standard total mesorectal excision (TME; aka low anterior resection, LAR) may vary depending on the specifics (e.g., size and stage) and the exact location of the target pathology (upper, middle, or lower third of the rectum). Sphincter preservation, restoration of intestinal continuity, temporary versus permanent ostomy, and respective functional and quality-of-life aspects are relevant aspects to be considered. Invasion of the pelvic floor or sphincter muscle or of other structures may require a more extensive resection (see Chaps. 50 and 51). Multimodality treatment and in some patients the presence of an underlying risk constellation (hereditary cancer, inflammatory bowel disease) may affect the decision-making and timing of surgery.

Preoperative Preparation

- Review the patient's history, diagnosis, functional aspects, and appropriate indication for surgery (based on endoscopic, clinical, or radiographic means) as opposed to diversion only or nonsurgical management (e.g., systemic chemotherapy).
- Accurate systemic and local tumor staging including, as appropriate:
  - Computed tomography (CT) of the chest abdomen and pelvis
  - MRI scan (rectal cancer staging protocol)
  - Endorectal ultrasonography
- Colonoscopy to determine the nature of the pathology (benign vs malignant), assess whether it is amenable to endoscopic removal, and to exclude synchronous pathology.
- Verify and measure the exact tumor level by number and in relation to the valves of Houston by means of an office endoscopy (rigid or flexible sigmoidoscopy) even if stated by a previous endoscopist (note: the tumor is often much lower than described).
- Multidisciplinary evaluation and discussion (particularly important in locally advanced tumors).
- Preoperative radiation and chemotherapy, if appropriate, to increase resectability of tumors with positive lymph nodes or threatened margins.
- In patients on chemotherapy or immunosuppressants or after radiation: Plan for optimal timing of surgery.
- Depending on the specifics (e.g., large tumor, severe inflammation): possible ureteral stent placement.
- Discussion and marking for possible ostomy.
- Mechanical bowel preparation.
- Antibiotic prophylaxis (versus treatment).

Pitfalls and Danger Points

- Oncologically inferior resection: violated mesorectal envelope, positive distal, proximal, or circumferential radial margin (CRM), insufficient lymph node harvest
- Anastomotic complications related to the following: tenuous blood supply to the distal or proximal margins, ten-

K. G. Cologne
Department of Surgery, Division of Colorectal Surgery, Keck School of Medicine of the University of Southern California, Los Angeles, CA, USA

A. J. Senagore
Kalamazoo, MI, USA

A. M. Kaiser (✉)
Department of Surgery, Division of Colorectal Surgery, City of Hope National Medical Center/Comprehensive Cancer Center, Duarte, CA, USA
e-mail: akaiser@COH.org

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sion on the anastomosis, axial twist, poor tissue quality (e.g., after radiation)
- Collateral injury: ureters, vagina, spleen, pancreas, autonomic nerves
- Hemorrhage: presacral veins, vascular pedicle, splenic flexure mobilization

Operative Strategy

Localization of Target Lesion

For any colorectal resection, exact localization of the target lesion is of utmost importance. That is even more important for rectal lesions, as the surgical approach and other treatment modalities must be contemplated and are affected by precise location. Rigid and/or flexible sigmoidoscopy is crucial to define the distance from the anal verge, the relationship to the valves of Houston, and the radial orientation. In contrast to colonic lesions, placement of tattoos in the rectum may result in blurring of dissection planes and on imaging may suggest a more advanced than true T- and N-stage. Availability of a flexible sigmoidoscope with CO_2 insufflation during surgery is crucial to allow for assessment during the case, to clarify the location, and also to visualize and test the anastomosis.

Surgical Approach

Traditionally, rectal surgery was approached and described as open surgery, for example, through a midline incision. Minimally invasive approaches (laparoscopic or robotic surgery), however, have dramatically evolved and in many circumstances are considered valid options. Safe surgery and cancer cure always carry a higher priority than the type of approach.

Oncologic Extent of Resection

Accurate preoperative staging and appropriate use of preoperative (neoadjuvant) chemotherapy and radiation therapy are important for optimal oncologic outcomes. The quality of the surgical resection for rectal cancer is defined by the lymph node harvest, and three critical margins: (1) the proximal (including adequate vessel ligation), (2) the distal, and (3) the circumferential margin.

The ability to achieve an adequate lymph node harvest depends on a precise dissection along the mesorectal fascia (*see below*) and an appropriate division level of the vascular pedicle. From an oncological standpoint, there is no difference between a ligation at the origin of the inferior mesenteric artery (Fig. 59.1) and a ligation at the run-off of the superior hemorrhoidal artery (Fig. 59.2). The decision about which level to choose should balance the needs to achieve adequate mobility and preserve a good blood supply.

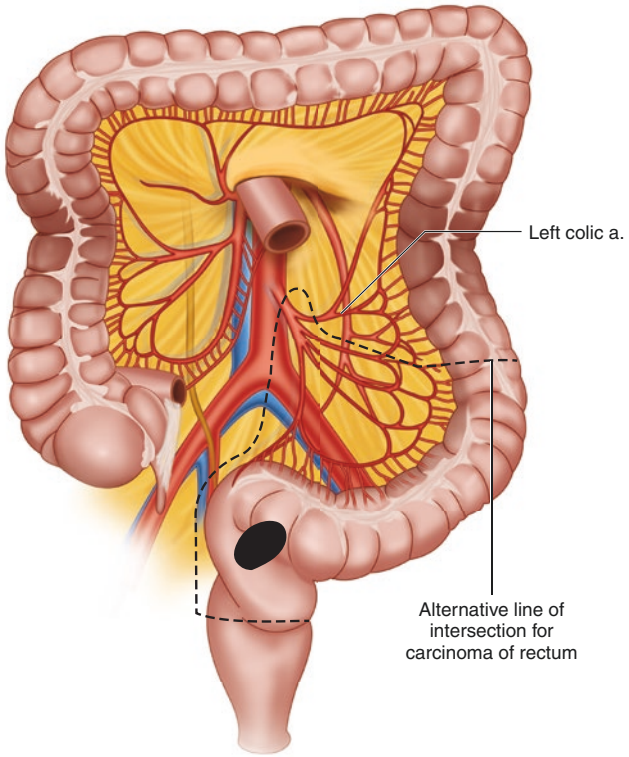

Fig. 59.1

The proximal margin is generally not problematic as a large amount of proximal rectum and sigmoid are routinely removed. Obtaining an adequate vessel ligation (usually just about the junction of the inferior mesenteric artery with the left colic and superior rectal artery) is critical for obtaining a sufficient lymph node yield. For the distal margin, current practice guidelines recommend 5 cm (if possible), though a closer margin of 2 cm is acceptable. In some cases, in order to preserve continence, up to a 1 cm distal margin is allowed in tumors of the distal rectum. Functional considerations must be discussed with the patient in these scenarios.

An adequate circumferential margin (defined as a minimum of 2 mm from the tumor to the cut edge of the mesorectal envelope) is best achieved by the technique of total mesorectal excision (TME) in the "holy" plane of avascular tissue that separates the fascia propria of the rectum from the endopelvic fascia. When properly performed, TME results in excision of a rectal specimen surrounded by an intact glistening envelope of fascia propria, in which lymphatics and associated lymph nodes are fully embedded. An adequate lymph node yield of at least 12 nodes should be reported; but after

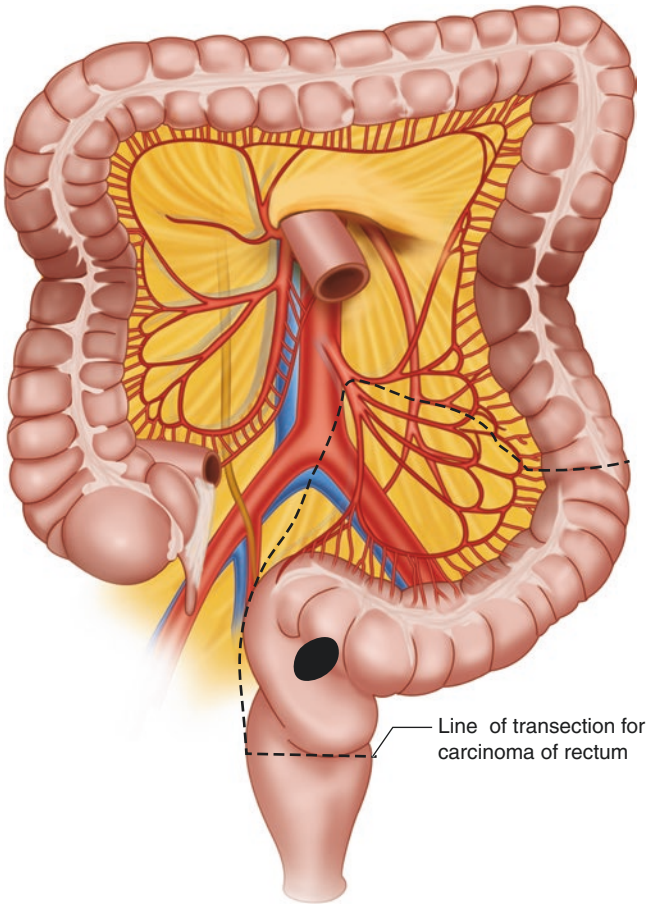

Fig. 59.2

neoadjuvant radiation, that number can occasionally be lower. Integrity of the mesorectal envelope is one of the quality parameters for the surgical specimen.

TME is rendered more difficult by obesity, bulky tumors, use of preoperative chemotherapy and radiation, and failure of the tumor to respond to preoperative therapy. TME is facilitated by early entry into the proper plane posteriorly and laterally and the use of precise dissection with adequate visualization and retraction.

Mesorectal Dissection

The concept of a total mesorectal excision (TME) technique should be applied to all rectal cancers. That standard approach requires that the surgeon carefully follows the mesorectal fascia in a specimen-oriented fashion. The "total" mesorectal excision applies to tumors in the distal third of the rectum. For higher tumors, the dissection is carried to an appropriate level below the tumor (ideally 5 cm distal margin), where the mesorectum and the bowel are divided in perpendicular direction to the axis of the bowel.

The presacral fascia and the fascia propria of the rectum are separated by a virtually avascular areolar tissue. Dissection in that space not only avoids the dangerous presacral vein plexus but also keeps the hypogastric nerve branches intact. Posteriorly, the two layers fuse above the coccyx and form Waldeyer's fascia. If the dissection needs to be carried further down, that fused fascia will need to be sharply divided in order to continue in the correct plane and not damage the rectum. Anteriorly, the rectal surface remains intraperitoneal down to the peritoneal reflection, which needs to be opened to follow the dissection along Denonvillier's fascia. The lateral dissection follows a line that connects the anterior and the posterior dissection. Even though this remaining tissue is often referred to as "lateral ligaments," there are no relevant ligament structures identifiable. At the level of the distal rectum, however, they contain mid rectal arteries and branches thereof.

Avoiding Collateral Damage

Structures at risk during a low anterior resection include the ureters (left and right), the hypogastric nerves, the presacral veins and branches of the interior iliac vessels, seminal vessels, vagina, and urethra. If the colon needs to be mobilized to allow for an anastomosis, the respective additional risks (e.g., splenic flexure) come into play as well. The best strategy to avoid injury to any of those structures is to understand their course as well as the various planes that are the result of the embryological development. Most importantly, however, the surgeon must recognize landmarks of the correct as well of an incorrect dissection. Repetitive verification particularly prior to transection of substantial tissue portions helps to minimize the respective risks. For example, the extra effort to revisualize the left ureter prior to dividing the vascular pedicle is several magnitudes smaller than dealing with the impact of a ureteral injury. It should be noted though that another potential point of injury to the ureter may be deep in the pelvis at the lateral aspect of the seminal vesicles.

The correct plane of dissection can be accessed either from the left or from the right side with a lateral-to-medial and a medial to lateral approach, respectively. From the left, the white line of Toldt is opened and the retroperitoneal structures carefully deflected. From the right side, it is easiest to incise the serosa in the triangle formed by the gently elevated vascular pedicle and the retroperitoneum. The areolar space just behind the major vascular arcade opens and leads into the pelvis when all other structures are gently pushed backward. Extension of the dissection along the areolar tissue toward the left and the pelvis almost automatically develops the correct pelvic dissection plane. The left ureter that crosses the common iliac artery and the gonadal vessels will remain below the dissection. At the same time,

the autonomic nerve plexus that follows the aorta and forms the hypogastric nerves before splitting into a right and left branch can be avoided. Their active preservation is necessary for normal bladder and sexual function. In males, injury causes retrograde ejaculation or even erectile dysfunction if injured low enough); in females, their sexual impact has not been well studied. Visualization of the aorta, vena cava, or of the iliac vessels, the psoas tendon, or the bare sacrum indicates that the dissection has gone too posterior into a wrong and dangerous place.

Locally advanced tumors, tumors with complications (perforation, abscess, etc.), or a previous surgery in the area renders the orientation and dissection clearly more difficult. Big tumors possibly threaten the circumferential margin and may require an extra-mesocolic dissection plane. Ideally, this situation should be anticipated from the preoperative assessment and not be a surprise at the time of surgery. The challenge of such a case is that the surgery may need to be more radical if cure is intended. Involved structures, including the hypogastric nerves, urogenital or bony structures, ought to be taken en bloc with the specimen (see Chap. 51). The more radical the approach, the more likely are resulting functional or anatomical alterations and dysfunctions, which are occasionally required and legitimate if necessary for adequate margins and potential cure. It is important to analyze and recognize if a tumor has a local extent with invasion beyond resectability and cure such that the optimal palliative measures have to be carried out.

The pelvis can be a dangerous place. The biggest hazard associated with its dissection is a massive hemorrhage which can be sudden and life-threatening. The plexus of presacral veins or branches of the internal iliac veins are the most common sources. Prevention is the best, decisive and swift action without panic the second-best approach to stay in control (*see later in section "Operative Technique"*).

Prevention of Anastomotic Complications

After a seemingly successful resection and intestinal restoration, anastomotic complications (bleeding, leak, stricture) are among the highest concerns. Specific challenges for the rectal anastomosis and areas for necessary investment of attention include:

1. Difficult anatomic exposure, particularly in men, obesity, and advanced or very low tumors. This interferes with the dissection, the transection of the distal rectum, viewing of the anastomosing process, and visualization and possible reinforcement of the anastomosis.
2. Poor tissue quality after chemoradiation: timing, interval, and overall dose are important parameters.
3. Denudation of the distal rectum, leaving an insufficient blood supply to the rectal stump and potentially weakening the bowel wall. For optimal outcomes, transect the mesorectum at a right angle to the proposed distal transection site. In contrast, skiving in on the mesorectum prior to division of the bowel wall may either result in ischemia (if too little mesorectum remains) or increased risk of local recurrence (if too much remains).
4. Large diameter of the distal rectum and insufficient clearance of the bowel wall, necessitating use of several stapler cartridges. Ideally, the transection should be completed with a single or at most two stapler firing(s). With increased number of stapler lines, the risk of ischemic corners and resulting leak goes up.
5. Failure to achieve perfect hemostasis in the pelvis may result in a hematoma which may get infected, develop into an abscess, and erode through the colorectal suture line or adjacent structures. Meticulous hemostasis is crucial, possibly using topical hemostatic agents, energy devices, or sutures. Placement of a drain in the dependent area is frequently recommended.
6. Size mismatch between rectal stump and proximal colon, resulting in "dog ears."
7. Tension on the anastomosis due to insufficient mobilization efforts.
8. Compromised blood supply on the proximal colon end as a result of denudation or aggressive mobilization efforts.
9. Areas of weakness on the proximal or distal bowel, for example, tear from insertion of the stapler sizer, or anvil, diverticula, etc.
10. A leak test should be performed whenever possible after completion of the anastomosis.

It has been the colorectal teaching all along that a diverting stoma proximal to the pelvic anastomosis does not reduce the incidence of an anastomotic leak but aims at reducing the septic sequelae thereof. The more severe the local manifestations of a complication are, the more intense of a fibrotic and stricturing response may ensue. If an anastomotic complication occurs, the chances to achieve a good functional outcome decrease significantly.

The Difficult Reach

One of the difficulties of a low anterior resection is to adequately mobilize the proximal colon to achieve a tension-free reach for a safe anastomosis. The bowel should retain an excellent blood supply to the very end and sufficient laxity to follow the sacral curvature.

Mobilization steps include the following: (1) release of lateral and retroperitoneal attachments up to and around the splenic flexure, (2) division of the left colic artery or base of the inferior mesenteric artery, (3) division of the

inferior mesenteric vein at the lower edge of the pancreas, (4) mobilization of the omentum and/or gastro-colic ligament, and (5) division of all attachments up to the middle colic artery.

If that is still not enough mobility, more aggressive solutions to overcome the distance between the two bowel ends include the following: (6) to transect the base of the middle colic pedicle for mobility reasons, (7) to guide the proximal colon end through the small bowel mesentery as the shortest distance, and (8) to not only transect the middle colic pedicle but also to mobilize and rotate the right colon in counter-clock fashion on the ileo-cecal pedicle and that way navigate around the bulk of small bowel loops.

Circulation through the marginal artery at a lower level must be pulsatile. Brisk flow should also be seen from a sharply cut edge of the colonic mucosa. Newer devices utilizing indocyanine green and fluorescence imaging technology can also help determine the adequacy of the blood flow. Poor blood supply leads to poor healing, the consequences of which can be devastating. Stricture, anastomotic leak, and other problems can result. Sometimes a mobilization step results in underperfusion and demarcation of the most distal segment of the proximal colon. Even if that part will have to be resected to a well-vascularized level, the net gain in length may nonetheless be worth the effort and allow for a tension-free anastomosis.

Technique of Anastomosis

The standard way to perform a pelvic anastomosis from an abdominal approach is to use a transanally inserted circular stapler. In select cases, a reversed stapled anastomosis can be carried out. Hand-sewn anastomoses in the deep pelvis are not impossible but highly cumbersome and have largely been phased out. The exceptions are ultralow resections with colo-anal anastomosis where the proximal colon can be pulled through the pelvic floor to mature the anastomosis from a perineal approach in hand-sewn fashion.

In addition to simply restoring the intestinal continuity, functional aspects may have to be considered for the colo-anal anastomosis. The loss of rectal reservoir function may be counteracted by some anastomotic modifications to augment the capacity and reverse the propulsive peristalsis: (1) colonic J-pouch-anal anastomosis, (2) colo-rectal side-to-end anastomosis, or (3) transverse coloplasty. It should be noted that these techniques are only appropriate after truly total mesorectal excisions with colo-anal anastomosis and should be avoided for higher rectal anastomoses. Furthermore, the beneficial impact on bowel frequency and urgency is most evident in the first 12–24 months; later the advantage disappears, and some patients develop the opposite, that is, stool clustering with fecal outlet obstruction.

Indications for Diverting Stoma (Colostomy or Ileostomy)

As mentioned previously, low pelvic anastomoses are at increased risk for leakage. While proximal diversion does not decrease the risk of a leak, it may mitigate the consequences of one. Unless the anastomosis is perfect in regard to all aspects (tissue quality, lax reach, excellent blood supply, negative leak test), a fecal diversion should be considered. Other relative indications for diversion include an anastomosis <7 cm from the anal verge, prior chemoradiotherapy, and increased operative blood loss.

Under most elective circumstances, a loop ileostomy is preferable to a transverse colostomy, as it is easier to take down and does not tether the colon in any way should subsequent colo-rectal surgeries become necessary.

The diverting stoma may be closed as early as 6 weeks after the low anterior resection if a healed anastomosis has been documented and no other treatments (e.g., chemotherapy, radiotherapy) have priority.

Documentation Basics

Coding for surgical procedures is complex. Consult the most recent edition of the AMA's *Current Procedural Terminology* book for details (see references at the end). In general, it is important to document:

- Findings and indication
- Reasoning for choice and extent of surgical resection
- Surgical approach
- Blood vessels taken
- Type of anastomosis, leak test
- Stoma creation

Operative Technique

Positioning

Regardless of the approach, place and secure the patient in modified lithotomy on an anti-sliding system that allows for dynamic repositioning during the case (Fig. 59.3a, b). Make sure that the perineum is at the table end to allow for access to the anus and that the hips can vary from flat (0 degree) to high lithotomy (90 degree). Preferably tuck both arms to allow best access. Place a urinary catheter to decompress the bladder and monitor intraoperative urine output. Prep and drape the patient from nipple line to mid thighs and include the perineal area and, in females, the vagina. Monitors for laparoscopic surgery should be placed such that surgeon, target, and monitor form one line (see Chap. 54, Fig. 54.2).

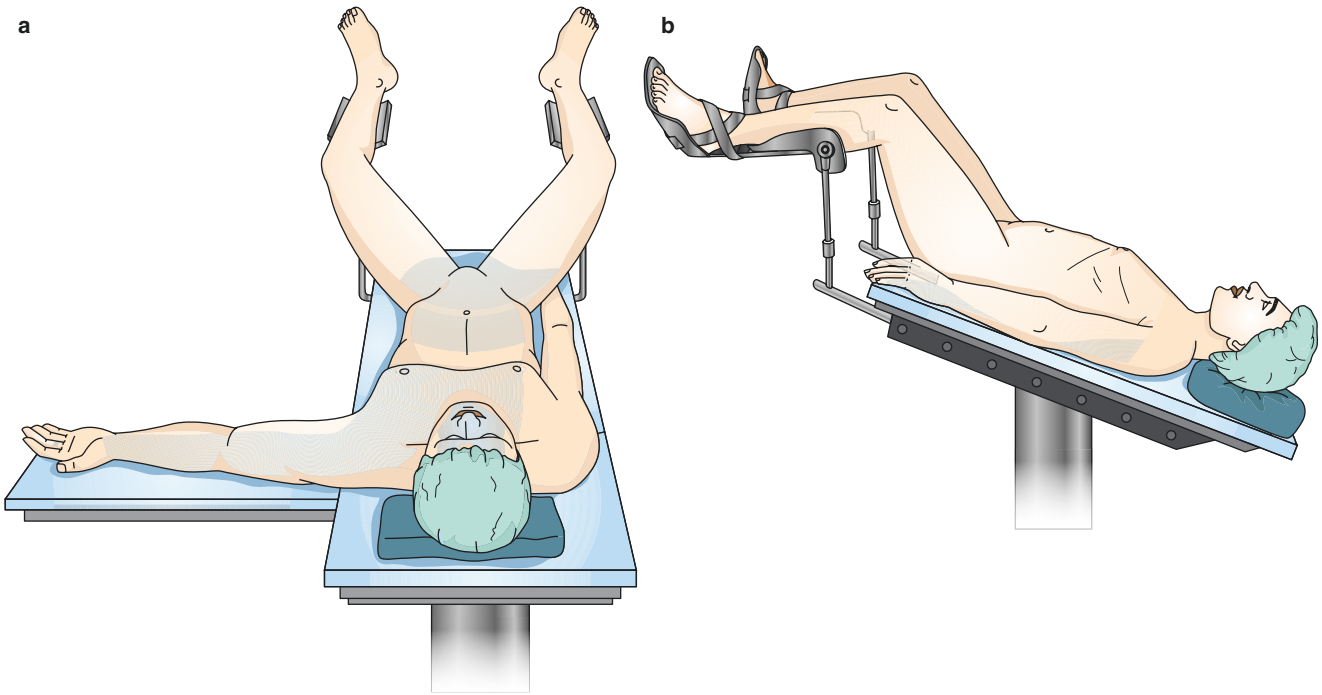

Fig. 59.3

Operative Approach and Incisions

Minimally Invasive Surgery

Each platform of minimally invasive techniques employs a slightly different layout of their port placement. Depending on the past history, insert the first 10–12 mm trocar using the Hasson or the Veress needle technique. Establish the pneumoperitoneum and insert the camera. Insert all subsequent ports under visual control.

Pure laparoscopic techniques normally use 4–5 trocars. Insert a camera port at the umbilicus. For specimen extraction and to a stapler anvil for the anastomosis, you can either later expand this incision or perform a separate access in a different location. Place 3–4 working ports that allow for triangulation toward the pelvis, the rectosigmoid, and the descending colon. Our preference is one in the right lower quadrant, one in the right middle to upper quadrant, and a third one in the left mid abdomen (see Chap. 55,). If necessary for the mobilization of the splenic flexure, insert an additional port in the epigastrium.

Placement of the robotic trocars depends on the platform. For the most current generation of robots (the DaVinci Xi), they are placed on an oblique line from the right iliac crest to the left upper quadrant with an additional accessory port in the right upper quadrant (see Chap. 55).

Open Approach

For an open approach, the surgeon works from the patient's left side, with the assistant on the right and a second assistant (if needed) standing between the patient's abducted thighs. Make a midline incision starting at the pubic bone and extending to the umbilicus. If this does not allow for sufficient exposure, extend the incision into the epigastrium by left circumference of the umbilicus (Fig. 59.4). Exposure is maintained by means of a self-retaining retractor such as a Bookwalter or Omni retractor with or without use of a wound protector. One advantage of keeping the incision below the umbilicus is that you can much easier tuck away the small bowel by means of a marked surgical towel that is held in by the upper abdominal wall alone.

Occasionally, a rectosigmoid resection is performed in conjunction with a liver resection. In that situation, it is good practice to discuss the needs of the different teams beforehand. Apart from a larger open incision, an alternative could include to perform the colorectal resection laparoscopically followed by an open liver resection (with an incision optimized for that procedure). In that case mark the planned incision for the liver resection and consider placing a hand port and slightly unusual laparoscopic ports along those lines.

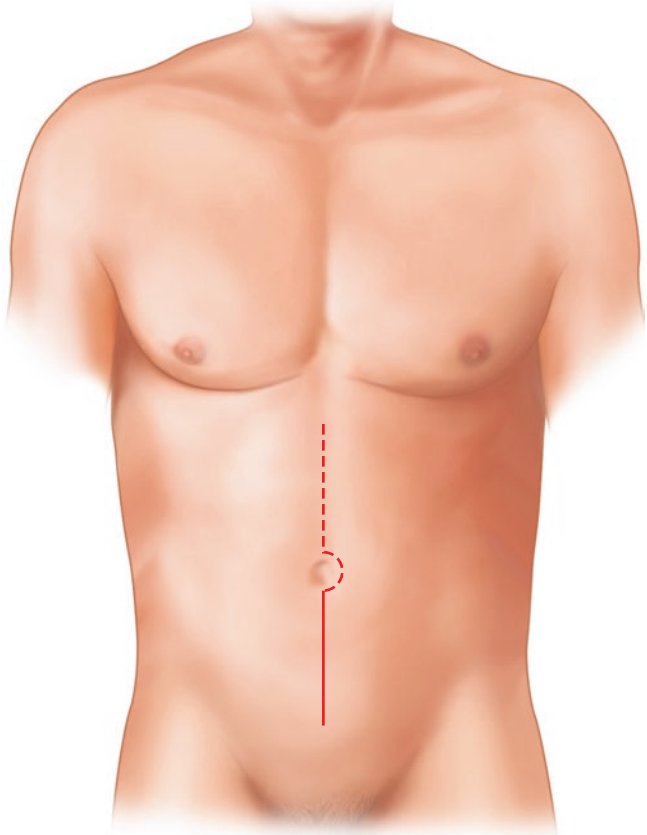

Fig. 59.4

Exploration

Once entry into the abdomen has been obtained (regardless of the platform), explore the abdomen. Perform and document a thorough examination of all quadrants and look for signs of tumor manifestations, for example, liver metastases, carcinomatosis, or Krukenberg tumors of the ovaries. Visualize or palpate the liver and peritoneal surfaces to assess for any metastatic disease. Carcinomatosis can be encountered in all quadrants but—if present—is particularly frequent in the pelvic cul-de-sac and the pericolonic gutters. Next, optimize the exposure to the primary pathology location. Even if there is little doubt regarding the location of the pathology, intraoperative colonoscopy with CO_2 insufflation should be available in the event that the level needs to be reassured.

Initial Colorectal Mobilization

Medial to lateral approach Leave the lateral attachments in place until the posterior mobilization is largely done. The attachments are a free assistant during the laparoscopic approach as they hold the colon up in place while you can work underneath. Once the serosa along the vascular pedicle is opened, you may elevate it and bluntly separate the colon along the avascular embryological planes. In order to preserve the hypogastric nerve plexus, it is important that you stay right underneath the vascular structures. Go as far as you can up to the extent needed for the resection. Pay close attention to not get lost too posteriorly where you could injure adjacent structures such as kidney, the jejunum at the ligament of Treitz, pancreas, or spleen by rough movements or hot instruments. Continue until the lateral peritoneal reflection has been reached. Only at that point, incise the lateral serosa and complete the mobilization. If necessary for reach purposes, you can continue the mobilization in proximal direction and perform a takedown of the splenic flexure.

Lateral to medial approach Commonly used in open surgery, this approach starts the mobilization of the sigmoid colon at the white line of Toldt. Using cautery, carefully incise the serosa along that line of embryological reflection (Fig. 59.5). Gently retract the colon and using a sponge-stick bluntly deflect the retroperitoneal structures including the ureter and gonadal vessels. Extend the incision in the peritoneum cephalad as far as the splenic flexure; then continue toward the pelvis and incise the serosa on both sides of the rectum. Use blunt dissection with a finger or a sponge-stick to carefully deflect the structures as you progress medially toward the pedicle and in caudad direction toward the pelvis. If you find yourself struggling, it is often because the dissection is in the wrong plane.

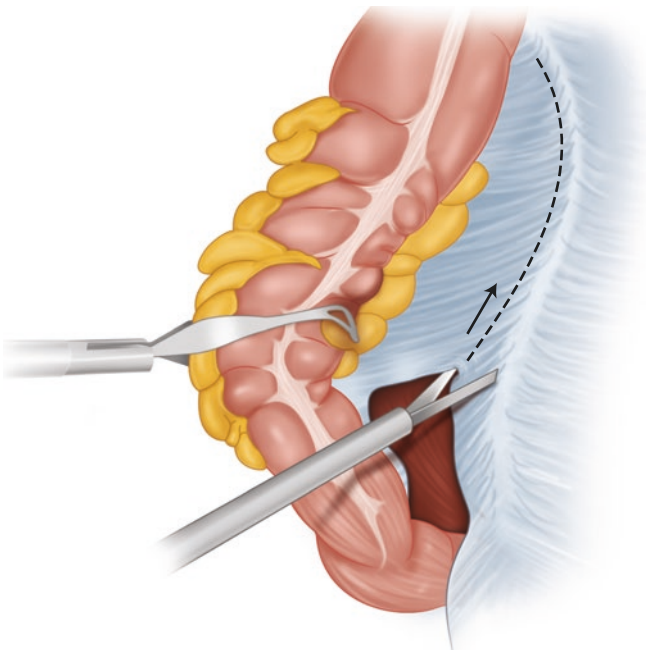

Fig. 59.5

Identification of the Ureters

For any rectosigmoid resection, make it a habit to always visualize the left ureter before transecting any relevant structures. In patients without visceral obesity, both ureters may be visible upon entry into the abdomen even without any dissection. More often than not, however, you need to free up the left ureter to see its wormlike peristalsis ("vermiculation") in the retroperitoneal fat. You may find it where it crosses the left common iliac artery near the bifurcation into the internal and external branches. If it is still not visible, you need to carry out a formal dissection which can either be a medial to lateral retroperitoneal dissection (laparoscopic/robotic) or a lateral to medial dissection (open). One of the pitfalls is that you get too posterior in the dissection and see the bare iliac vessels or the psoas muscle with its white tendon. Reassess the dissection plane and go more anteriorly. Once you have positively identified the ureter, you may facilitate its subsequent localization throughout the case by placing a clip just anteriorly to the fat, or by tagging it with a silastic vessel loop. Identify the course of the ureter well down toward the lateral pelvic sidewall (Fig. 59.6). Not only identify the left ureter but visualize the location of the right ureter as you open the serosa on that side. Remember also that the ureters may suffer injury deeper in the pelvis when you dissect the lateral aspect of the seminal vesicles.

If you have doubt whether you might have caused an injury to the urinary tract, instruct the anesthesiologist to inject indigo carmine dye intravenously and look for blue extravasation into the surgical field. Alternatively (and certainly if you anticipate difficulty in identifying the ureters), consider placement of ureteral stents.

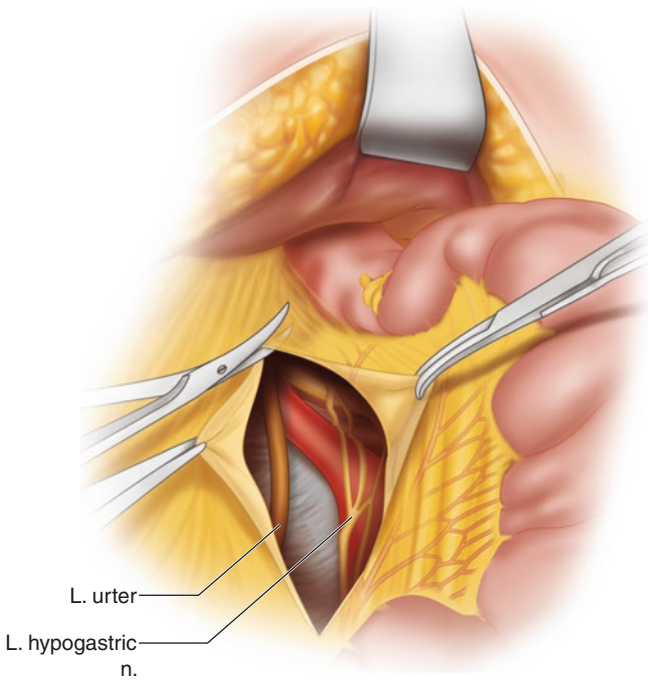

Fig. 59.6

Division of the Blood Supply (IMA Pedicle, Mesentery)

Grasp the mesentery at the sigmoid and elevate and retract it to the side. This maneuver will accentuate the inferior mesenteric artery pedicle. In order to increase the amount of lymphatic tissue in the specimen, plan on taking the vascular pedicle as close as possible to its point of origin. For a rectosigmoid resection, it may suffice that you only take the superior rectal artery (aka superior hemorrhoidal artery) but leave the left colic branch in place. If the sigmoid colon does not seem to be very redundant and you anticipate a need to perform a systematic mobilization in order to perform a low anastomosis, it may be prudent to rather take the inferior mesenteric vessels at their origin (*see below*).

Incise and score the peritoneum along the base of the mesentery from the right-sided base of the vascular pedicle to the beginning of the rectum at the pelvic brim. This will open up the avascular plane directly behind the superior vascular arch. If you go too far posterior, you risk injuring the hypogastric nerve and get on the wrong track into the pelvis.

Use gentle but directed blunt dissection by tenting the cut edge of the peritoneum anteriorly and caudad to lift the mesentery off the retroperitoneal structures. Again identify and push down the left ureter, gonadal vessels, and hypogastric nerves during this step of the procedure. Using instrument or finger dissection, widen the space by more caudad blunt dissection of the areolar tissue of the relatively avascular plane. Any bleeding indicates that the dissection is either too high within the mesocolon or too deep within the retroperitoneum. If significant bleeding is encountered, reorient yourself and ensure that you are in the proper tissue spaces. You should feel or see posteriorly the aortic and/or iliac pulsation and anteriorly the pulsation of the inferior mesenteric artery. It is not desirable to skeletonize down to the anterior wall of the aorta, as it impacts the hypogastric nerves and could result autonomic nerve dysfunction.

Isolate the vascular pedicle by sharply incising the peritoneum overlying the origin of the inferior mesenteric artery at the junction to the left colic and superior rectal arteries. In routine cases divide the inferior mesenteric vessels about 2 cm after the takeoff from the aorta. In obese patients, you may need to thin out the pedicle by pinching it between your fingers or stepwise dissect portions of the fat off. Before transecting the pedicle, reidentify the ureter to ensure it is adequately dissected posteriorly downward and will not be caught up in any clamps or stapler applied to the pedicle.

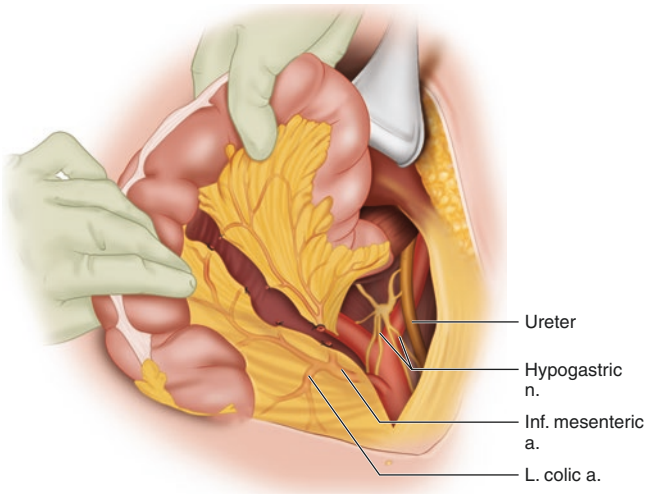

Fig. 59.7

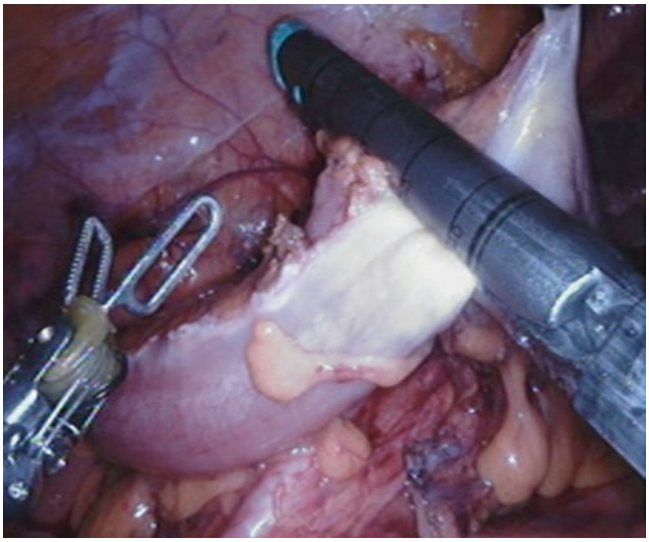

Fig. 59.8

Transection of the vascular pedicle after triple checking the location of the ureter can be achieved in different ways: (1) by clamping, sharp dissection, and suture ligation; (2) isolation of each vessel, clipping, and sharp dissection; (3) vascular linear stapler; or (4) advanced energy devices.

Divide the intervening mesentery up to the bowel wall at the planned transection point by following the superior rectal artery within the mesentery (Fig. 59.7). Keep all tissue associated with this vessel in the planned resection specimen to ensure adequate lymph node yield. In nonobese patients, it is feasible to incise the peritoneum up to the point where a vessel is visualized and then apply hemostats directly to each vessel as it is encountered. Alternatively, an energy device or clamp and tie method may be used throughout.

Proximal Bowel Transection

Once you have come across the marginal artery in a similar fashion and freed up the bowel wall, you may transect the colon. Use of a linear stapler is advantageous as to minimize contamination of the surgical field (Fig. 59.8). Sweep the proximal end of the colon away in the packing until later when you prepare it for construction of the anastomosis.

Splenic Flexure Mobilization

Depending on the level of the planned pelvic anastomosis, the splenic flexure of the colon may have to be completely mobilized. You can do this either before the actual resection in anticipation of the need to mobilize or you first do the resection and reassess the factual needs at that point.

Additional steps to assure appropriate mobility to reach include that you (1) divide the artery at the run-off from the aorta, (2) have mobilized all retroperitoneal attachments, (3) mobilize the splenic flexure, (4) divide the inferior mesenteric vein at the lower edge of the pancreas, and (5) free up all nonvascular tissue up to the middle colic artery while carefully preserving the marginal blood supply.

In rare circumstances (mostly reoperative cases), you may have to continue the mobilization much further and divide the middle colic artery below the level where it branches into left and right. This aggressive mobilization will require that there is an adequate perfusion from the right colonic branches and the marginal arteries.

Pelvic and Presacral Dissection

Maintaining the integrity of the mesorectal compartment during a total mesorectal excision (TME) is a key element of quality surgical technique and improves the outcome.

Use scissors or monopolar electrocautery to continue incising the peritoneal reflection along the left and right side of the rectum down to the rectovesical or rectouterine pouch of Douglas. At the pelvic brim, identify the course of the left ureter and bluntly sweep this it out of the way using a sponge stick, St. Mark's retractor, or forceps. This will ensure it does not get accidentally caught during later dissection. Recheck the position of the right ureter and carry the right serosal incision down toward the peritoneal reflection. Optimize the exposure and in front of the rectum, "connect the dots" of the serosal incisions previously made on the right and left sides of the rectum (Figs. 59.9 and 59.10). If the exposure is not yet adequate, delay this step until the presacral dissection allows to sufficiently elevate the rectum and bring the rectovesical pouch better into the field of vision. A uterine retraction suture can also aid the exposure, particularly if the

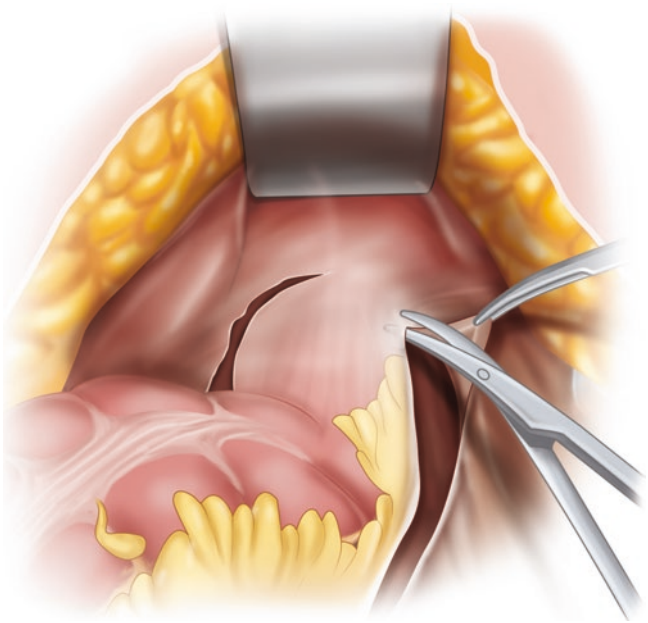

Fig. 59.9

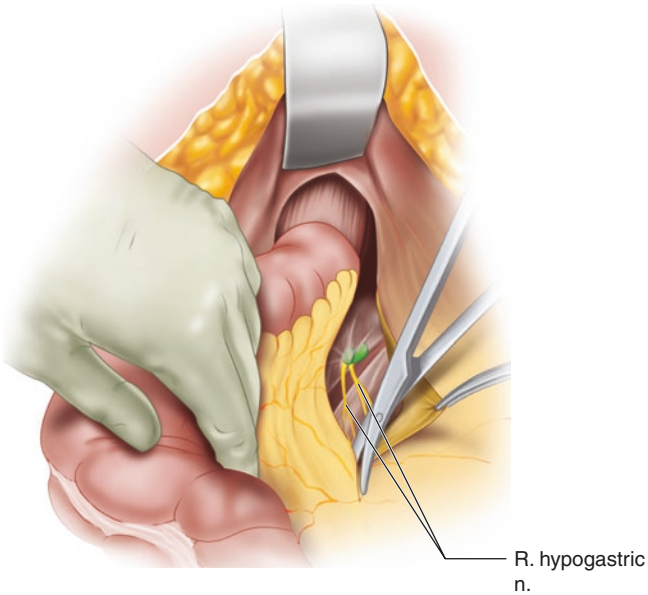

Fig. 59.10

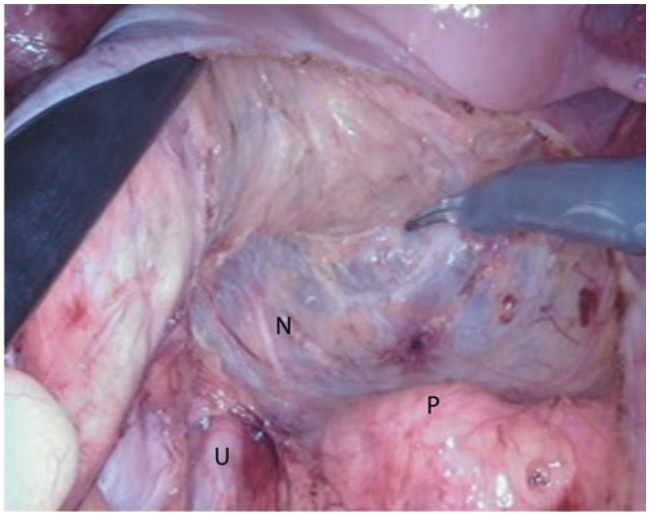

Fig. 59.11

surgery is done with a minimally invasive platform. You can place this either in the uterus fundus or through the avascular part of the lateral ligaments and around its body.

Retract the proximal end of the rectosigmoid and develop the avascular plane with areolar tissue between the presacral fascia and the fascia propria of the rectum. If you have entered the correct space at the level of the vascular pedicle and follow it toward the pelvis, the transition to the correct plane should be automatic. Staying in that plane is crucial to avoid immediate complications and long-term functional impairment (Fig. 59.11). You should and can avoid the dangerous presacral vein plexus and the autonomic hypogastric nerves which divide into two major trunks in the upper sacral area and continue laterally to the right and left pelvic side wall. Insert a retractor behind the rectum and carefully elevate the mesorectum. Use gentle but decisive frontward traction to dissect the avascular "holy" presacral plane. Readjust retraction every few centimeters, and the dissection should rapidly proceed without much difficulty until the two fascial layers fuse a few centimeters above the coccyx and form Waldeyer's fascia. In order to continue the posterior dissection further down, you will have to sharply divide the Waldeyer's fascia, which extends from the lower sacrum to the posterior rectal wall (Fig. 59.12).

Readjust the retraction and extend the posterior dissection toward the sides and continue to deflect the hypogastric nerves. Make sure that by this point, you have incised the entire serosa all the way to the peritoneal reflection. Retraction of the rectosigmoid in cephalad and contralateral direction places the remaining lateral tissue (aka lateral "ligaments") on stretch. On either side, divide this tissue between the anterior and the posterior dissection along the pelvic sidewall. Advanced energy devices are enormously helpful to do this fairly swiftly without causing any relevant bleeding.

Now direct your attention to the anterior dissection. Use a deep and potentially lighted retractor (e.g., St. Marks retractor) to pull the genito-urinary structures (men: bladder, seminal vesicles, prostate; women: uterus, vagina) in an anterior and cephalad direction. Identification of Denonvillier's fascia in this lower portion is important for the total mesorectal excision (TME). Optimized retraction optimizes the dissection. In open surgery, you may apply one or more long Allis clamps to the anterior lip of the incised peritoneum and pull

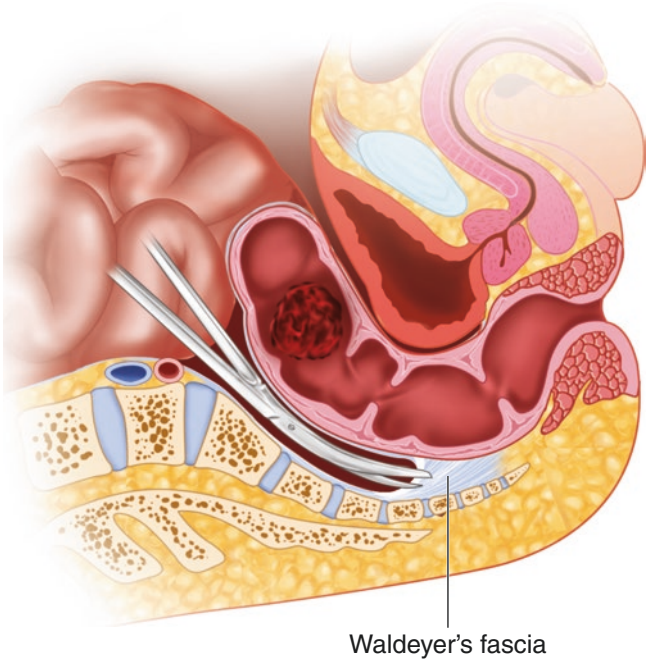

Fig. 59.12

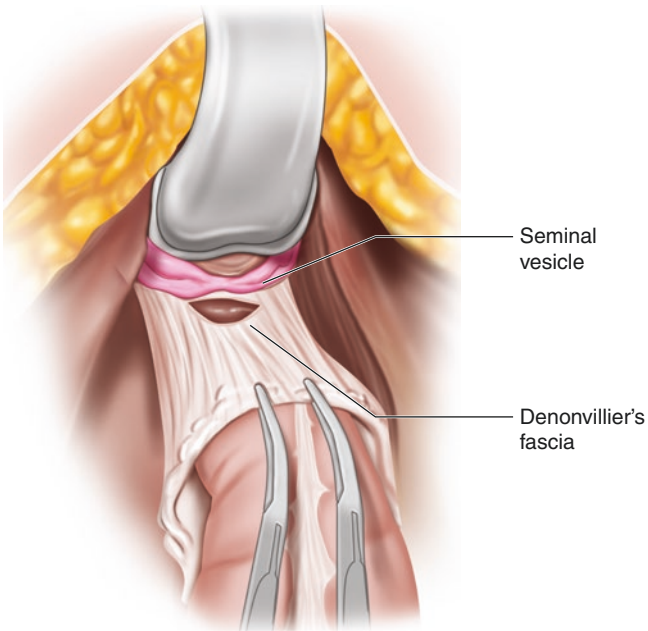

Fig. 59.13

it to the front. When you retract at the same time the rectum up and push it toward the sacrum, the proper tension and counter tension provide you with access to the anterior plane. To separate the rectum from the seminal vesicles and prostate or from uterus and vagina, respectively, use sharp dissection along the visible lines of tension (Fig. 59.13). If no lines of tension are seen, readjust the retraction until the plane becomes evident. Use a sweeping or rocking motion with the deepest tip of the retractor to separate the rectum from the anterior structures. Continue the dissection until you reach a sufficient level below the tumor. Ideally, that would be 5 cm, but for tumors in the distal third of the rectum, 2 cm or even less may be sufficient.

Pelvic Hemostasis

Pelvic blood loss should be minimal if the dissection follows the correct TME planes. Very large tumors and previous radiation may result in a general hypervascularity of the area. Among the most feared causes of severe pelvic hemorrhage are injuries to the presacral vein plexus or major branches of the interior iliac vein. Hemostatic clips, suture ligations, and targeted repair of a ripped larger vein are necessary to control bleeding from a clearly identified source along the lateral wall of the pelvis. Posteriorly in the presacral area, however, these measures are not useful. Here the vessels consist of thin-walled veins, which are easily torn by metallic clips at the time of application or during the act of sponging the area later. Almost invariably, presacral bleeding results from a tear in one or more of the veins that drain into a sacral foramen. Except in the case of a small, clearly defined bleeding point that can be held in forceps, mechanical maneuvers (suturing, clipping, cautery) may be hazardous, as they may act as a scalpel and convert the bleeding point to a major venous laceration.

If a major bleeding occurs, initiate a quick damage control sequence whereby a number of maneuvers can be carried out individually or in combination:

- Pack the pelvis with firm pressure for 10–15 minutes and until other maneuvers have been arranged for.
- Place the patient in more steep Trendelenburg position to reduce the venous pressure.
- Apply direct energy using cautery at high and arching settings or bipolar sealer systems (e.g., Aquamantys™).
- Apply fast-acting hemostatic agents followed by continued packing.
- Apply thumbtacks.
- Harvest a 1 cubic cm muscle (e.g., from the abdominal wall), press it against the bleeding area and applying high cautery energy.
- Isolate and clamp the iliac arteries to temporarily reduce the arterial inflow.
- Assure in discussion with the anesthesiologist that the patient has an appropriate coagulation profile. If not, consider systemic administration of pro-coagulative factor products.

Unless these maneuvers produce complete hemostasis, replace the dense sponge pack in the presacral space, abort

the further surgery, and transfer the patient to a monitored unit. Plan for a reexploration 24–48 hours with removal of the packs and ideally continuation of the resection.

Distal Rectal Transection

The rectum in the upper and middle third is partially intraperitoneal and in the back accompanied by an often bulky mesorectum that contains the arcade of the superior hemorrhoidal artery. In the distal completely extraperitoneal rectum, the mesorectum thins out while being more circumferential. If there is sufficient length below the tumor, select a transection point that is 5 cm distal to its lower border; otherwise perform a total mesorectal excision.

For a partial mesorectal excision, divide the mesorectum at a right angle to the proposed transection point until the bowel wall with its longitudinal muscle fibers is visible all around. You can either use bipolar electrocautery, an advanced energy device, or manual clamping and ligating. For total mesorectal excision (TME), continue to follow the mesorectal envelope until the pelvic floor musculature is completely freed up.

In the majority of cases, divide the rectum by means of a cutting stapler device (Contour, or endoscopic linear stapler), or place a large right-angle clamp across the entire lumen of the rectum and staple-close the rectum distal to it with a TA stapler, followed by scalpel division of the bowel. Your goal should be to come across the bowel with a few stapler firings as possible.

For ultralow resections, the last part of the dissection is performed transanally from a perineal approach. The abdominal dissection should have been completed down to the pelvic floor. Then switch to the perineum, install a Lone-Star retractor and incise the lining at the dentate line. Depending on the oncological needs, the transanal dissection can lift the mucosa off the internal anal sphincter muscle before extending full-thickness through the distal rectal wall and connect with the abdominal dissection. Occasionally, short of an abdomino-perineal resection, you may sacrifice the internal sphincter muscle and immediately target the intersphincteric groove to travel in cephalad direction.

Irrigation of Rectal Stump

If there is any question as to the adequacy of the bowel preparation, insert a rubber catheter and irrigate the area with dilute betadine. Beyond removing stool, there is surgical dogma but little scientific evidence that the irrigation as such reduces local tumor recurrences by removing any free-floating tumor cells.

Anastomosis

The type and approach for the anastomosis depends on the level above the pelvic floor, the space within the pelvis, and the mobility of the proximal colon. In the upper and mid rectum, a stapled (or rarely hand-sewn) end-to-end anastomosis is the typical approach. Only for the complete TMEs with a "colo-anal" anastomosis just above the pelvic floor, you may consider an alternative to a straight end-to-end configuration in order to increase the reservoir and reduce urgency. Among the options are a side-to-end anastomosis (Baker), a colonic J-pouch, and a transverse coloplasty in stapled or hand-sewn sutured technique.

Double Stapled Anastomosis (Abdominal and Perineal Access)

If you divided the rectum distal to the tumor by means of a stapling device, the most straightforward anastomosis is done in a stapled end-to-end fashion (i.e., the name "double-stapled") as described for the sigmoid resection.

Place a non-crushing bowel clamp roughly 10 cm proximal to the stapled proximal bowel end. Cut off the staple line and assess the bowel end for appropriate perfusion and bleeding. Grab the bowel end with two Allis clamps and place a full-thickness purse-string suture using a monofilament 2-0 suture. Make sure to find the balance between too few and too many bites. Alternatively, you may use a disposable purse-string device which you place close to the stapled end, fire, and liberate the suture ends; trim the bowel flush to the device and at the same time remove the staple line. Secure the anvil of a circular EEA stapler (commonly between 29 and 33 mm, rarely 25 mm) with a hemostat clamp. Gently insert it into the open proximal bowel and make sure not to cause any wall tears. Tie the purse-string suture. Trim the edge of the proximal bowel by removing the attached appendices. Ensure that no diverticula or other bowel wall defects are in the area of the anastomosis. For laparoscopic approaches, return the proximal bowel with the anvil into the abdominal cavity and reestablish the pneumoperitoneum.

There should be sufficient slack in the colon to fill the hollow of the sacrum on its way to the site of the anastomosis. If not, perform additional lengthening maneuvers to achieve sufficient slack (high ligation of IMA pedicle, divide IMV at inferior border of pancreas, mobilize splenic flexure and disconnect all retroperitoneal attachments, divide omentum off the colon wall, divide mesentery up to the superior rectal artery, tunnel the bowel through window in small bowel mesentery for shorter route to pelvic floor).

One of the team members needs to move between the legs to introduce the corresponding body of the circular stapling device into the rectum. Gently dilate the sphincter complex with two fingers and insert a bowel sizer to accommodate the stapling device. Intravenous administration of glucagon by

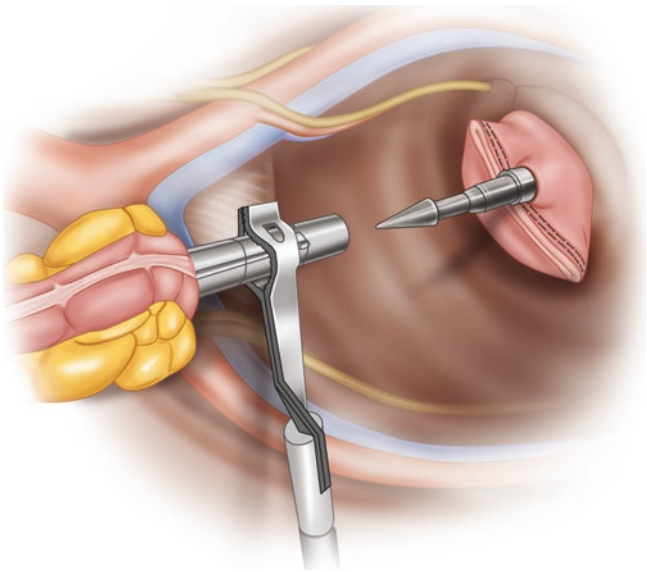

Fig. 59.14

the anesthesiologist may aid in relaxing the bowel spasticity. Advance bowel sizers of increasing size to the end of the rectal stump to ensure that there are no strictures, adhesions, or other defects that would impede the path of the stapling device. Insert the stapling device and advance it to the end of the staple line.

Deploy the stapler spike immediately next to the staple line (Fig. 59.14). If the stump is thin or if the transverse staple line becomes disrupted, a 2-0 atraumatic Prolene over-and-over whipstitch can be used on the rectal stump. Each bite should contain 4 mm of full-thickness rectal wall, and the stitches should be no more than 6 mm apart to prevent gaps when the suture is tied.

In open or hand-assisted laparoscopic cases, grasp the proximal end and perform the connection. For laparoscopic cases, an anvil grasper is helpful to connect the anvil (proximal bowel) with the spike in the rectum. The camera can be repositioned as needed so that the entire team can visualize both the distal and proximal portion of the anastomosis. Once coupled, verify the correct bowel axis and slowly close the stapling device. Target the middle compression area, if the specific stapling device offers a variable closing range; some devices have only a single firing position. During the slow closing maneuver, make sure that any extraneous tissue (appendages, urogenital structures) is actively reflected away, that there is no tension, and proper alignment prior to the firing. For females, place a finger in the vagina and gently move the stapler side to side to ensure that no vaginal tissue is caught in the staple line. Decisively fire the stapler. Partly open its mechanism with three half-turns and gently remove the device.

Check the completeness of the stapler donuts and the integrity of the anastomosis: Fill the pelvis with irrigation fluid. Gently compress the colon proximal to the anastomosis using two fingers or a non-crushing bowel clamp. Insufflate the rectum in controlled fashion with air using a rigid or a flexible sigmoidoscope. The latter is more equipment-intensive but has the advantage that you can also visualize the anastomosis. The abdominal team observes the anastomosis for air leaks. If leaks are present, your options are (1) to oversew and recheck, (2) to take down and redo the anastomosis, or (3) to abandon the anastomosis. Even if you elect to divert the anastomosis, it is advisable that you optimize it locally beforehand. If you have to redo the anastomosis, but there is not sufficient space for a re-resection with the stapler, it may be necessary to remove the residual rectum to the dentate line and perform a hand-sewn colo-anal anastomosis.

Hand-Sewn Colo-anal Anastomosis (Perineal Access)

Once the abdominal dissection has reached the pelvic floor, switch to the perineal approach (*as described above*). With a Lone-star retractor in place to expose the anal verge, finish the rectal mobilization and connect with the abdominal dissection. This allows you to pull the entire rectum downward. Prior to doing so, the abdominal dissection should have included an adequate proximal mobilization such that the intended proximal transection site easily reaches the anal verge.

Before shortening the bowel to appropriate length, verify the blood supply. If mobility allows, pull a little bit more out and start securing the bowel to the pelvic floor muscles using a total of eight absorbable seromuscular sutures. Gradually transect the bowel at the appropriate level and send the resection specimen for gross inspection and a frozen section of the distal margin. If the margin is negative, complete the colo-anal anastomosis by placing interrupted full-thickness sutures between the four-quadrant sutures and potentially fine-tune the mucosa with a running 3/0 chromic suture (Fig. 59.15).

Reversed Stapled Circular Stapler Anastomosis (Abdominal Access)

In rare cases (e.g., unanticipated intraoperative consult and need for resection), you may not have access to the anus to insert the circular stapler. You may open the rectal stump and place a purse-string suture. Insert the anvil and tie the purse-string suture. About 10–15 cm from the end of the stapled off proximal colon, perform a 3 cm longitudinal colotomy. Insert the stapler body through that opening and advance it to the stapled colon end. Deploy the spike and connect it with the anvil in the rectal stump. Carry out the

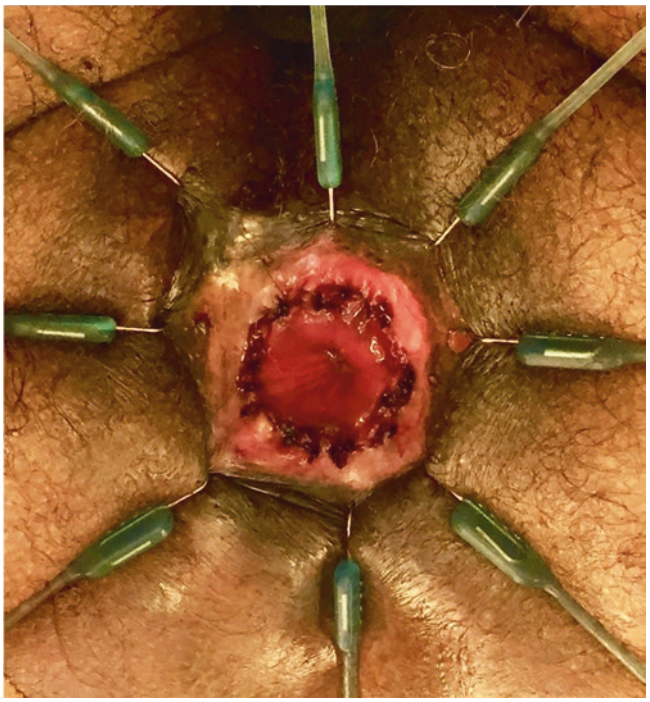

Fig. 59.15

anastomosis. Remove the stapler and close the colotomy in transverse direction. That can be done with a transverse stapler or handsewn in two layers.

Variations of Colo-anal Anastomosis (To Improve Short-Term Function)

If there is sufficient space, sufficient length, and a colo-anal anastomosis needs to be fashioned, you can augment the reservoir by one of these variations. The benefits are short term (first 12–24 months). If the neorectum has a large diameter such that it theoretically could easily accept a 33 mm circular stapler anvil, use of these augmentations is not necessary even if possible.

Colonic J-pouch Instead of a straight anastomosis, you can form a 5–6 cm long colonic J-pouch by folding it, opening the apex and placing the two jaws of a linear stapler on either side. Place a purse-string suture to the apical enterotomy, insert the stapler anvil and connect the J to the transanally inserted stapler, or suture it transanally to the dentate line.

Baker anastomosis (side-to-end) Instead of inserting the stapler anvil into the end of the proximal bowel, you attach the spear to the anvil and insert that in backward direction to the proximal end. Penetrate with the spear on the side. Staple off the true open end of the bowel. Connect the anvil with the transanally inserted stapler.

Transverse coloplasty You may insert the stapler anvil just as if you do when performing a straight stapled anastomosis. Before doing so, however, make a longitudinal roughly 4 cm incision to the bowel (colotomy) roughly 4 cm proximal to the anvil. Place two holding stitches on either side in the middle of the colotomy and pull them aside. Close the colotomy in two layers in transverse fashion.

Pitfalls, Danger Points, and Troubleshooting Stapled Anastomoses

Staplers have been a great asset for pelvic anastomosis which overall have become safer and more predictable. However, they cannot guarantee a perfect anastomosis. Keep in mind that a proximal diversion does not compensate for a bad anastomosis. It is best to fix problems right then and there when everything has already been freed up. Consider how bad the alternative of a future redo-surgery with dense adhesions and an even more difficult pelvic dissection may be if the first anastomosis does not heal favorably.

Bleeding

Immediate bleeding may be related to incorporation of the mesentery. Delayed bleeding could indicate an anastomotic leak or also be related to the staple line. If possible, a visualization of a significant bleeding site should be considered with clipping or suturing of the respective area.

Anastomotic failure

Signs of an immediate anastomotic failure are an obvious separation of the staple lines, tearing of the bowel wall proximal or distal to the anastomosis, incomplete donuts, and/or a positive leak test. If there is a leak, your options are (1) to oversew and recheck, (2) to take down and redo the anastomosis (if necessary by complete pull-through and handsewn colo-anal anastomosis), or (3) to abandon the anastomosis all together and perform a permanent stoma. Even if you plan on diverting the anastomosis, it is advisable to optimize it locally beforehand.

Incorporation of urogenital structures

This is a severe technical complication which should be largely preventable. Prevention is better than correcting the issue. Before completely closing the stapler, verify that those structures are neither fully included nor even tethered in the stapler. Reopen it if you are not sure. Only close the stapler to the firing range when you are sure that the urogenital structures are actively kept out of the closing stapler.

Stapler insertion impossible

Analyze the reasons. If there is truly a stricture that for some reasons you were not aware of, determine whether a hand-

sewn anastomosis or a reversed stapled anastomosis would be doable and have a chance for a good functional outcome, or whether you should abandon the plan of an anastomosis.

Anastomosis not prudent

Even if you originally planned a restorative pelvic or coloanal anastomosis, intraoperative specifics of the cancer or the anatomy may be unfavorable such that it may simply not be prudent to pursue the plan. Examples (other than the inability to reach) include persistent tumor along the pelvic passage, extremely poor tissue quality, active pelvic infection, insufficient passage to allow the normal size colon to fit through, and others.

Wound Closure

The operating team should discard soiled gloves and use new instruments to close the surgical wounds. If available, cover the anastomosis with the remaining omentum to aid in healing and deterrence of leak. Consider placing a pelvic drain. Perform a last check of the abdomen. Remove the ports and/or retractors. Close the fascia of any incision larger than 5 mm in routine fashion. Irrigate the wound before closing the skin.

If a diverting stoma has been planned, mature it after all skin has been closed (see Chap. 45).

Postoperative Care

- Antibiotics: Routine coverage for the perioperative 24-hour period. In case of an underlying infection/sepsis, continue respective therapeutic antibiotics for that indication.
- Intravenous fluids: Maintain adequate fluid until return of bowel function.
- Nasogastric tube: No routine use in elective cases; keep it in non-elective cases until evidence of return of bowel function.
- Enhanced recovery after surgery (ERAS) protocol: In elective cases, initiate oral intake on day of surgery and advance to solid food as patient demonstrates return of bowel function.
- Nutritional support: If return of bowel function delayed by more than 5 days, initiate parenteral nutrition.
- Incentive spirometry and early ambulation should be encouraged.
- If adjuvant chemotherapy or radiation therapy is planned, this can usually be initiated 4–6 weeks after surgery.
- A temporary stoma can be reversed after a minimum of 6–12 weeks if there are no other treatments that have priority (e.g., adjuvant chemotherapy), and if the integrity and patency of the anastomosis has been documented by means of the clinical exam, endoscopy, and a water-soluble contrast study.

Complications

- Collateral organ injury (ureters, pelvic urogenital structures, hypogastric nerves, major vessels, spleen).
- Surgical site infection: superficial (abdominal wall) versus deep (anastomosis).
- Anastomotic leak/pelvic sepsis:
  - Pelvic sepsis secondary to an anastomotic leak is among the most serious and potentially lethal complications following a low colorectal anastomosis. It should be suspected until proven otherwise in any patient with fever, leukocytosis, tachycardia, and/or nonresolving ileus. Clinical manifestations of this complication may develop at any time, but not infrequently occur 5–9 days after surgery.
  - A gentle digital examination of the rectum may be diagnostic if the finger discloses a defect in the suture line, which often is located on its posterior aspect.
  - Careful endoscopic examination with minimal CO_2 insufflation may disclose evidence of a defect in the suture line and provide information about the perfusion of the two sides.
  - An abdomino-pelvic CT scan can almost always confirm the presence of pelvic sepsis, particularly when combined with administration of rectal contrast through a catheter without balloon insufflation. The CT modality may further aid in draining of pelvic fluid collections.
  - Vigorous management is important: The treatment depends on (1) the acuity of the patient and (2) whether the patient has already been diverted. Patients with mild systemic symptoms who are suspected of having a pelvic infection may be treated by bowel rest (nil per os), intravenous broad-spectrum antibiotics, and possibly hyperalimentation. Stable patients can be treated by CT-guided percutaneous catheter drainage or trans-rectal drainage with or without proximal diversion. A patient may have a pelvic abscess even in the absence of a definite defect in the suture line. Consequently, a patient who is febrile and toxic should undergo drainage of any septic process that is identified.
  - Sick patient requiring ICU transfer or with signs of sepsis require return to the operating room to clean out and drain, divert, or possibly take apart the anastomosis.
- Anastomotic bleeding: immediately (technical), early postoperative (staple line, leak), long term (ischemia, recurrence).

- Anastomotic stenosis (e.g., as a result of ischemia, scarring, particularly after previous leak).
- Postoperative ileus or small bowel obstruction.
- Autonomic nerve dysfunction (particularly after triple hit by chemo- and radiotherapy and surgery):
  - *Bladder dysfunction* may follow low anterior resection, especially in men with benign prostatic hypertrophy. Generally, the function resumes after 6–7 days of bladder drainage, possibly supported by an alpha-adrenergic antagonist.
  - *Sexual dysfunction* in men may follow low anterior resection, especially in patients with large tumors and who require extensive dissection of the presacral space, lateral ligaments, and prostatic area.
- Low-anterior-resection syndrome (LARS): bowel and pelvic floor dysfunction with sometimes incapacitating urgency, tenesmus, bowel frequency, incontinence, or stool clustering.
- Incisional, port-site, or internal hernia formation.

Further Reading

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