28 Minimally Invasive Management of Complicated Sigmoid Diverticulitis in the Emergency Setting: Patient Selection, Prerequisite Skills, and Operative Strategies

Ron G. Landmann and Todd D. Francone

Introduction and Rationale

Complicated diverticulitis is defined as diverticulitis with associated abscess, phlegmon, fistula, obstruction, bleeding, or perforation with purulent or fecal peritonitis [1]. National guidelines for the management of diverticular disease continue to evolve with the pendulum swung in full force toward a more conservative approach, individualized for both complicated and uncomplicated diverticulitis. These guidelines have also been modified to include minimally invasive surgery as a safe and effective modality for diverticular disease. This is mainly in part related to the increased utilization of robotic and laparoscopic approaches for not only benign disease but also malignant processes.

As with the decision to operate, the technique should be tailored to the individual. No matter the choice of technique, open or minimally invasive, surgery for complicated diverticulitis comes with inherent challenges due to perforation, sepsis, abscess, fistula, and peritonitis. Surgical options vary between the historically conservative Hartmann's procedure (HP) with segmental colectomy and end colostomy, segmental resection with primary anastomosis (PRA) with or without fecal diversion, and, the least invasive approach, laparoscopic peritoneal lavage (LL).

Safe and effective management of complicated diverticulitis requires a personalized approach to the patient based on the clinical presentation, diagnostic imaging,

R. G. Landmann
Section of Colon and Rectal Surgery, Department of Surgical Oncology, Inflammatory Bowel Disease Center, Baptist-MD Anderson Cancer Center, Jacksonville, FL, USA

T. D. Francone (✉)
Newton/Wellesley Hospital, Newton, MA, USA

Massachusetts General Hospital, Boston, MA, USA

Tufts Medical University, Boston, MA, USA
e-mail: tfrancone@partners.org

P. Sylla et al. (eds.), *The SAGES Manual of Colorectal Surgery*,
https://doi.org/10.1007/978-3-030-24812-3_28

Box 28.1 Hinchey Classification
- *Stage Ia:* phlegmon
- *Stage Ib:* diverticulitis with pericolic or mesenteric abscess
- *Stage II:* diverticulitis with walled off pelvic abscess
- *Stage III:* diverticulitis with generalized purulent peritonitis
- *Stage IV:* diverticulitis with generalized fecal peritonitis

Data from Refs. [2–6]

Box 28.2 Indications for Surgery with Complicated Diverticulitis
1. Hemodynamic instability
2. Failure to respond to medical therapy (i.e., percutaneous drainage of abscess and IV antibiotics)
3. Fistula disease (colovesicular, colovaginal, colocutaneous)
4. Large bowel obstruction with impending perforation
5. Gastrointestinal hemorrhage.

and underlying disease presentation such as the presence of purulent (Hinchey III) or feculent (Hinchey IV) peritonitis (Box 28.1). For these reasons, it is essential to be familiar with various approaches (i.e., medial-to-lateral, lateral-to-medial, superior to inferior, etc.) resulting in optimal exposure as well as safer, quicker, and a more reproducible dissection in an otherwise hostile surgical environment. This chapter aims to provide insight into the considerations required and techniques available to safely perform minimally invasive surgery for complicated diverticulitis.

Indications and Contraindications

The management of patients with peritonitis from perforated diverticulitis is challenging. Patient presentation may vary from hemodynamically stable to critically ill and labile. Accordingly, rapid and accurate diagnosis and evaluation is essential to facilitate selection of an appropriate surgical strategy. Indications for surgery in patients with complicated diverticulitis include the presence of diffuse peritonitis such as in patients with Hinchey III or IV disease, failure to respond to medical therapy such as with percutaneous drainage or IV antibiotics, or the development of complex disease such as a fistula to the vagina or bladder (Box 28.2). As one would expect, bowel resection in the setting of acute inflammation can be quite problematic and potentially detrimental to the patient with increased risk of injury to other critical structures. As such, nonoperative management, such as percutaneous drainage and intravenous antibiotic therapy, should always be considered and favored in patients who are not critically ill. A study by Dharmaarjan and coauthors demonstrated that 93% of patients with remote air on CT scan were able to be managed effectively nonoperatively with almost 50% of patients eventually undergoing an elective minimally invasive resection highlighting the importance of correlating clinical assessment with diagnostic imaging [7].

The decision to perform minimally invasive surgery in the setting of complicated diverticulitis should be based not only on the physiologic state and comorbidities of the patient but also the experience of the operating surgeon and surgical team. In the hemodynamically stable patient, laparoscopy offers both diagnostic and therapeutic utility, including drainage of abscesses, lavage, or bowel resection. The decision to proceed in a minimally invasive fashion or convert to an open approach is multifactorial. Factors such as poor exposure, difficult anatomy, and patient intolerance related to cardiopulmonary status or failure to make progress highlight the importance of an experienced surgeon to recognize when the benefit of a minimally invasive approach is dwarfed by the risk to patient safety.

Although an open approach does not necessarily resolve all the difficulties encountered during those complex cases, it may allow certain advantages such as increased exposure and the ability to palpate structures as well as the use of blunt dissection. In the setting of purulent or feculent peritonitis, aggressive abdominal irrigation may also be facilitated. Those familiar with hand-assist laparoscopy may be able to avoid conversion to an open procedure as this technique utilizes the advantages of both minimally invasive and open techniques. Whatever the approach, the surgeon and the operating room staff should frequently reevaluate the intraoperative conditions to ensure there is appropriate prioritizing of patients' safety and that procedures are progressing in a safe and effective manner.

Principles and Quality Benchmarks

The goals of treating patients with complicated diverticulitis remain simple: (1) stabilize the patient and (2) control the sepsis. Once achieved, definitive management can be determined. In the critically ill patient with physiologic compromise, MIS should be avoided, and damage control techniques may need to be employed. The principles of damage control surgery in non-trauma care include abbreviated surgery to control contamination in the abdomen, simultaneous resuscitation, and definitive surgical management at a later stage after restoration of hemodynamic stability. The staged management of damage control has been shown to minimize the physiological impact of shock, allowing definitive reconstruction under more favorable conditions. In the setting of perforated diverticular disease, the patient may be taken to the operating room for exploratory laparotomy where the segment of perforated diverticular disease is resected with minimal dissection or simply diverted. Diversion can be achieved with either a diverting loop sigmoid colostomy, transverse colostomy, or "blow hole" [8]. The abdomen is thoroughly washed with irrigation, and the patient is transferred to the ICU for further resuscitation with plans for more definitive care once stable [9].

There is minimal benefit to "damage control" techniques in the setting of hemodynamic stability. Less critical patients may be considered for a minimally invasive approach although the principles of concurrent physiologic resuscitation and sepsis control remain relevant. The source of sepsis should be identified and controlled either by diversion or resection. Resection is often feasible; however, the surgeon should avoid extensive dissection along the retroperitoneum and avoid mobilizing the splenic flexure if possible. This may not be possible in certain situations, especially in the morbidly obese when a diverting colostomy can be difficult to create in the setting of a thick abdominal wall. Once the sepsis is controlled, primary definitive care may occur at the time of the initial operation. If resection is performed, the potential for restoring intestinal continuity should be considered. Alternative management to resection in patients with mainly Hinchey III disease includes laparoscopic lavage and is discussed later in the chapter in detail.

Preoperative Planning, Patient Workup, and Optimization

In the emergency setting, extensive preoperative workup and planning are often precluded by the need for urgent operative intervention. In the critically ill patient, operative intervention may be required before further diagnostic imaging such as a CT scan can be performed; however, preoperative optimization, either in the emergency department or surgical intensive care unit with IV fluid resuscitation, IV antibiotics, as well as potentially afterload reduction or inotropic support may reduce intraoperative events and improve postoperative outcomes. Additionally, improved hemodynamic status may allow opportunity for further diagnostic imaging including CT scan to further narrow the differential diagnosis and etiology.

Physiologic state notwithstanding, clinical assessment should at minimum include a detailed medical history including prior operative interventions as well as an appropriate physical exam and laboratory workup. Past medical history includes prior endoscopic evaluation such as colonoscopy. This is particularly important in patients who present with perforation secondary to large bowel obstruction raising the possibility of a neoplastic etiology in the absence of a prior endoscopic evaluation. Hemodynamic stability often affords more time for a detailed clinical history and physical exam habitually supplemented by a CT scan of the abdomen and pelvis. Identification of free air or fluid throughout the abdomen may give further clues to the classification of the presenting diverticular disease with categorization into Hinchey I–IV (Box 28.1) and as such dictate further management. In the absence of free fluid or diffuse air throughout the abdomen, nonoperative management should be considered as the preferred pathway. Failure to respond to medical management should trigger conversion to an operative approach. Patients with presumed Hinchey III diverticular disease may be considered for laparoscopic lavage with the understanding that delineation between Hinchey III and IV can be challenging and may require conversion to a bowel resection either by laparoscopy or open. Other preoperative considerations may include ureteral stents depending on availability at the time of surgery.

Routine mechanical bowel preparation should be performed if possible, for left-sided resections, and is recommended in the elective setting in conjunction with oral antibiotics as per enhanced recovery protocols [10]. Elective resection with primary anastomosis without bowel preparation has been shown to be safe and feasible; however, if fecal diversion is deemed necessary, then an on-table lavage should be performed to reduce the fecal load proximal to the new anastomosis. Fecal diversion will have minimal benefit if the colon distal to the diverting ostomy is full of stool. On-table lavage has been shown to be safe but can be time-consuming and expose the patient to unnecessary risk with increased fecal contamination, bowel handlining, and ileus [11]. The authors do not generally perform nor advocate for on-table lavage.

It also is worth noting that all patients undergoing emergent operation for presumed diverticular disease receive preoperative stoma marking and teaching. It is well documented that a well-sited stoma and pre-counseling have been associated with improved postoperative outcomes and higher quality of lie scores [12]. Often a Wound Ostomy Care Nurse (WOCN) is not available; therefore, it is up to the surgeon to discuss the possibility of a stoma, provide adequate education, and appropriately mark potential sites. Both the right and left sides of the abdomen should be marked for potential stomas in preparation for either Hartmann's procedure or segmental resection with primary anastomosis and loop ileostomy creation. Stoma creation without considerations of certain factors such as prior scars, belt lines, and abdominal crease can result in a poorly functioning stoma no matter how well it is fashioned.

Operative Strategy

Operative strategy will be dictated by multiple factors including but not limited to the physiologic state of the patient, medical comorbidities, prior surgical history, diagnostic imaging suggesting feculent or purulent peritonitis, timing of presentation, as well as the experience of the surgeon and surgical staff. Consideration of these factors among others should aid the surgeon in devising a strategic operative plan for the patient, in particular whether to approach the patient using a minimally invasive approach. Furthermore, any patient planed for a minimally invasive approach should be prepared the possibility of conversion to an open procedure.

When operating in an emergent hostile abdomen, it is essential to be familiar with various approaches for dissection of the bowel and its mesentery (i.e., medial-to-lateral, lateral-to-medial, superior to inferior, etc) in order to optimize exposure, perform a safer and quicker dissection, and minimize the risk of injury and postoperative morbidity. This is undoubtedly facilitated by a fundamental understanding of the surgical anatomy, allowing the surgeon to identify key anatomic landmarks such as the bladder and ureters prior to proceeding with planned resection while being prepared to perform additional diagnostic evaluations and therapeutic interventions as needed.

Surgical options can range from sigmoid resection with end colostomy, well known as a Hartmann's procedure (HP), sigmoid resection with primary anastomosis (PRA) with or without temporary fecal diversion, or laparoscopic lavage (LL). Recent systematic reviews and meta-analyses have reported comparable complication rates for those undergoing PRA and HP suggesting that PRA is safe and feasible in the setting of generalized peritonitis (Hinchey III and IV). Results have been less favorable for laparoscopic lavage with data suggesting no clear benefit to lavage when compared to PRA or HP [13, 14]. In a recent meta-analysis by Schmidt and coauthors, mortality rates were similar between HP and PRA (RR 2.03 (95% CI 0.79–5.25); $p = 0.14$) but showed higher stoma reversal rates for those patients undergoing PRA (RR 0.73 (95% CI 0.58–0.98); $p = 0.008$). In addition, the meta-analysis showed no significant benefit of laparoscopic lavage when compared to resection, with similar mortality (RR 1.07 (95% CI 0.65–1.76); $p = 0.79$) and morbidity rates (RR 0.86 (95% CI 0.69–1.08); $p = 0.20$), respectively [14].

Diagnostic laparoscopy is first performed to inspect the abdominal and pelvic cavity to evaluate for any altered anatomy and discern for feculent peritonitis not previously identified on preoperative staging and imaging. For the most part, the decision to convert from minimally invasive to open should occur early in the operative intervention with studies demonstrating improved patient outcomes with proactive conversion rather than reactive [15]. The decision to restore intestinal continuity at the time of emergency resection rather than diverting with an end colostomy can be challenging. The surgeon has to consider multiple factors including the patient's condition, the condition of the bowel and the amount of fecal load proximal to the anastomosis, the risk of morbidity and mortality based on comorbidities, as well as the potential for long-term impact on the patient's quality of life. Primary anastomosis with or without mechanical bowel preparation has been shown to be safe and feasible. If the fecal load above the new anastomosis is considerable, then on-table lavage should be considered.

Operative Setup

The following patient setup can be utilized for any procedure (resection, lavage, or fecal diversion). Patient positioning and port placement may need to be adjusted based on the patient's prior surgical history, body habitus, and pathology.

Patient Positioning

Patients are positioned on gel pads or bean bags with safety straps or tape to minimize patient slipping and movement during extremes of positioning (Trendelenburg and reverse-Trendelenburg, right or left-side tilt). Furthermore, all patients are placed in modified lithotomy (legs in slight hip flexion) or split-leg position with both arms tucked at the sides (Fig. 28.1). Positioning in this manner affords the

Fig. 28.1 Patient setup. Patient is placed in the split-leg position for all cases

surgeons numerous advantages including (1) insertion of a stapling device and (2) exposure to the anus/rectum for intraoperative colonoscopy if needed. This can be particularly useful to help rule out a tumor that may not have been appreciated on preoperative workup, as well as to assess the anastomosis endoscopically for integrity and adequate perfusion (3) operator positioning between the legs during more complex procedures.

Port Placement

Appropriate port placement is critical in facilitating exposure and anatomic definition. For a left or sigmoid colectomy, a total of four "working" ports are utilized (12 mm umbilical, 12 mm right lower quadrant (RLQ), 5 mm right upper quadrant (RUQ), 5 mm left lower quadrant (LLQ)) (Fig. 28.2a). An open cut-down technique (Hasson technique) is used to place a supra-umbilical port and then utilized for introduction of the 10 mm laparoscope. This allows for initial exploration. The RLQ trocar is used for the endoscopic stapler. The LLQ port is often helpful for assistance with retraction and possible drain placement. For a hand-assist approach, access to the peritoneal cavity is achieved by making a 6–8 cm Pfannenstiel incision (Fig. 28.2b); however, in cases that have high probability of conversions to an open

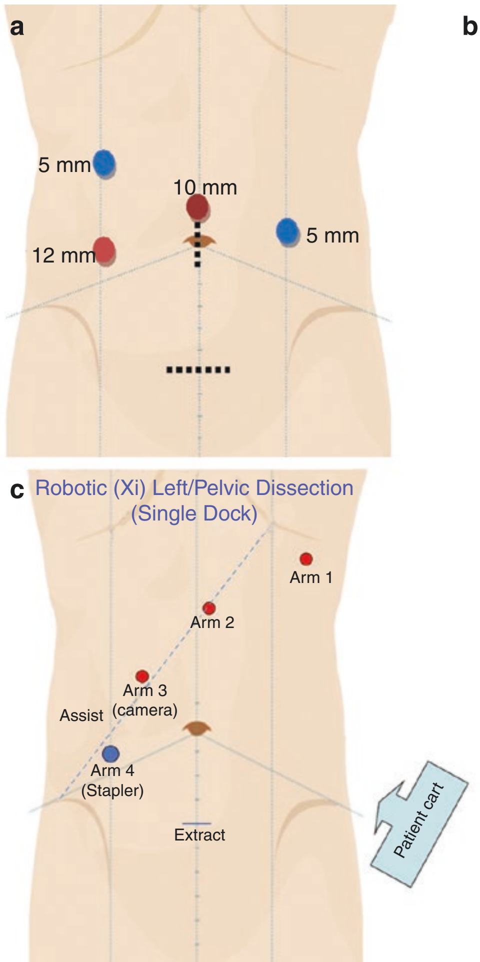

Fig. 28.2 (**a**–**c**) Port setup. (**a**) Depicts a laparoscopic four-port technique. Abdominal access is typically achieved via the Hasson technique, and a 10 mm port is placed. The two ports in the right upper and lower quadrant are utilized as working ports. The 4th port is placed on the left side of the abdomen and is typically used for additional retraction. This port maybe excluded as one gains more experience. Extraction can vary with surgeon preference. The diagram depicts the extraction site (dotted line) in the two most common locations. (**b**) Hand-port port placement. (**c**) Port placement for Xi Robotic approach with supra-pubic extraction site

procedure, a lower midline incision may be used as it can be easily extended cephalad if conversion to an open procedure is warranted. For elective procedures with complex disease such as colovesicular or colovaginal fistulas, robotic surgery techniques may be utilized. Port placement for an elective left colectomy is demonstrated in Fig. 28.2c.

Diagnostic Laparoscopy

The patient is placed in Trendelenburg position with the left side tilted up, which assists in displacing the small intestine into the upper abdomen. Prior to any mobilization or resection, inspect the abdominal and pelvic cavity to rule out feculent peritonitis and localize abscesses or phlegmons and evaluate their relationship to the sigmoid colon. It is also appropriate to take this opportunity to visualize the pelvis including the relationship of the inflammatory sigmoid mass to the bladder, left pelvic sidewall and retroperitoneum, ovaries, adjacent colon and small bowel loops, and anterior peritoneal reflection. The small bowel should also be thoroughly inspected to assess the degree of peritonitis and the likelihood that a minimally invasive approach is feasible.

Identification of Pathology

The pathology is often identified during diagnostic laparoscopy at which point adjustments to the preoperative surgical plan may be required. In the setting of perforated diverticulitis, the extent of peritonitis will dictate whether minimally invasive approach is feasible. The identification of feculent peritonitis is often difficult to control with minimally invasive techniques, even hand-assist, and is typically associated with conversion to an open procedure. Patients with purulent peritonitis (Hinchey III) may only require laparoscopic lavage.

Those who present with large bowel obstruction may be difficult to resect due to chronic inflammation such that fecal diversion may be the safest option. In this circumstance the entire large and small bowel should be inspected to rule bowel compromise which may present as large serosal tears or even frank perforation. If there is a concern for malignancy, then an intraoperative colonoscopy is warranted if feasible and temporary fecal diversion may be in the patient's best interest. Subsequently, the patient may undergo appropriate staging, allow inflammation to settle, and subsequently undergo an appropriate oncologic resection in the future. Pathology located in the proximal sigmoid colon or distal descending colon may necessitate mobilization of the splenic flexure for appropriate tension-free anastomosis or fecal diversion.

Minimally Invasive Resectional Approach

Critical Steps of Resection

Best Approach

In the elective setting, a medial-to-lateral approach is the author's preferred approach. However, in the setting of a perforation, the anatomy of the left lower quadrant, pelvis, and retroperitoneum is often distorted. The retroperitoneum at the

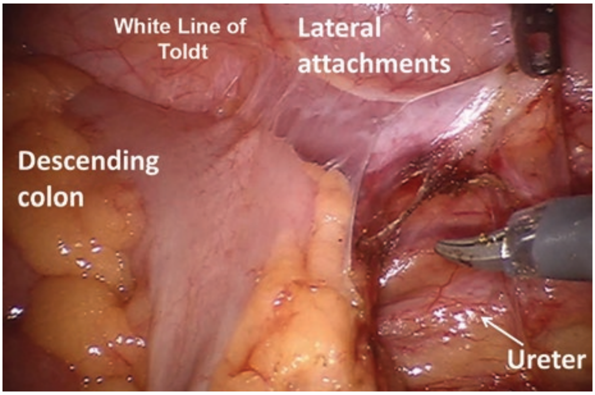

Fig. 28.3 When dividing the lateral attachments, dissection is carried from the pelvis toward the splenic flexure

site of the perforation is often inflamed such that critical retroperitoneal structures can be challenging to identify or kept out of harm's way. A phlegmon may involve loops of small bowel or densely adhere the colon to the pelvic sidewall. For this reason, a lateral-to-medial mobilization is most useful and safe especially in the setting of benign disease where regional lymph node harvest is not of importance (Fig. 28.3). The colon mesentery needs only to be mobilized enough for resection leaving much of the colonic mesentery in place overlying the retroperitoneum and avoiding injury to critical structures such as the left ureter. The dissection should be started above the pathology typically along the proximal descending colon where the planes are less inflamed. The correct plane is followed as the dissection is extended toward the pelvis.

Identifying the Vascular Anatomy

The inferior mesenteric artery (IMA) is typically preserved during an emergent operation. The takeoff of the IMA occurs roughly at the level of L3 vertebrae. The IMA and its branches are the vascular supply to the hindgut structures including the distal transverse, descending, and sigmoid colon, as well as the rectum. Leaving the IMA intact preserves blood flow to the proximal colon and rectal stump while also avoiding the retroperitoneum and circumventing the potential risk of injury to underlying structures.

Identification of the Left Ureter

Given the left ureter's close proximity to the rectosigmoid and left pelvic sidewall, it is often at risk for becoming secondarily involved from diverticular inflammation. Therefore, it is particularly vulnerable to injury during emergent surgery for complicated sigmoid diverticulitis. It lies under the parietal peritoneum along the pelvic sidewall and rests on the anterior surface of the psoas muscle (Fig. 28.4a, b). The right and left ureters generally both follow a straight path from the renal pelvis to the pelvic brim and then cross over the iliac vessels to enter the pelvic brim. The right ureter classically traverses the external iliac artery, whereas the left ureter lies slightly more medial and typically crosses the common iliac artery. The ureters then

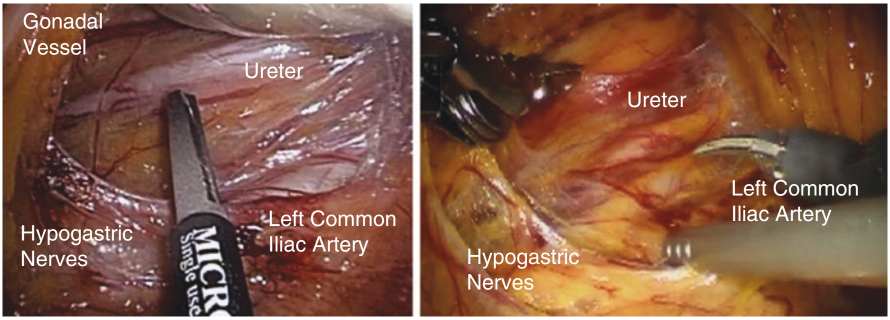

Fig. 28.4 (**a**, **b**) Pelvic anatomy highlighting the ureter, gonadal vessels, sacral promontory, hypogastric nerves, and avascular alveolar space between fascia propria and presacral fascia

run posterior and inferior along the lateral pelvic sidewall before entering the posterolateral surface of the bladder to form the trigone. If possible, avoiding extensive mobilization in a lateral-to-medial fashion should avoid injury to the ureter and other underlying retroperitoneal structures such as the left gonadal vessels and the hypogastric nerve plexus.

If the underlying disease and circumstances dictate a more extensive retroperitoneal dissection, the ureter must be visualized and dissected out to avoid inadvertent injury. In cases where the ureter is not easily identified, it is prudent to alter the approach and mobilization to ensure that it is visualized prior to mesentery or bowel transection. In certain cases, the ureter may have been mobilized medially and placed on stretch with the mobilized left colon mesentery. Alternatively, it may be involved in a phlegmon and require dissection to free it. The latter cases require a different approach to dissect the colon mesentery safely away from the left ureter to avoid transection. In the non-emergent setting, preoperative ureteral catheters/stents placement can be particularly helpful to aide in laparoscopic palpation of the ureters. Though these stents do not reduce the risk for transection or injury, they do permit for earlier identification of these events and facilitate prompt repair.

Splenic Flexure Mobilization (If Needed)

Splenic flexure mobilization is typically not required when performing an HP unless the patient is morbidly obese and with a thick abdominal wall or PRA is planned. Splenic flexure mobilization is generally performed using a combination of approaches. A lateral-to-medial approach is our preferred approach in the emergency setting. The patient is placed in reverse Trendelenburg position with the table inclined toward the right. Laterally, the peritoneal attachments to the abdominal sidewall and spleen are carefully divided while being mindful not to injure the splenic capsule (Fig. 28.5). Often, there will be close and dense adhesions of the colon to the spleen. The hand-assist technique can also be advantageous in this scenario. The lesser sac can be entered and used to direct the dissection around the splenic flexure and safely mobilize left colon (Fig. 28.6). Dissection continues separating the attachments of the splenic flexure and its mesentery away from the spleen and pancreas.

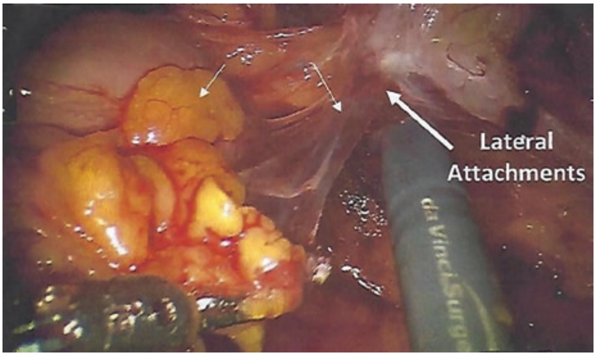

Fig. 28.5 The attachments to the sidewall and spleen are carefully divided while being mindful not to injure the splenic capsule

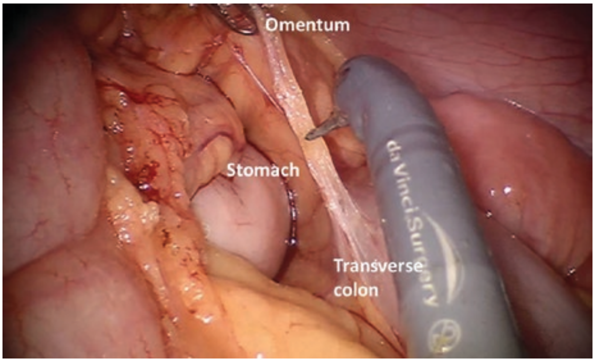

Fig. 28.6 The lesser sac is identified by visualization of the posterior wall of the stomach. Often, congenital fusion attachments must be divided to enter the correct space. Entry into the lesser sac often facilitates complete mobilization of the splenic flexure

Resecting the Source of Sepsis

Once the colon is adequately mobilized and the left ureter identified and protected, bowel resection is carried out. In the setting of a large perforation, the proximal and distal colon should be divided laparoscopically to control contamination. The mesentery is then divided using an energy device or stapler. Staying close to the colon will avoid injury to the underlying structures of the retroperitoneum. In the setting of a phlegmon or perforation, tissues are often friable, necrotic, and ischemic with little bleeding. The mesentery is divided caudally until the site of distal transection is reached.

Distal Colon Transection

A critical step in any left or sigmoid resection is identification of a distal transection point. The colon should be soft and viable. If planning a Hartmann's procedure, then a lengthier rectal stump can be utilized. The superior hemorrhoidal arteries can be left intact ensuring the retroperitoneum is undisturbed facilitating possible reversal of the colostomy in the future.

When planning a primary anastomosis, division is generally performed at the level of the proximal rectum, past the splaying of the tenia coli on the anti-mesenteric surface. For diverticular disease, this minimizes recurrence by transection distal to

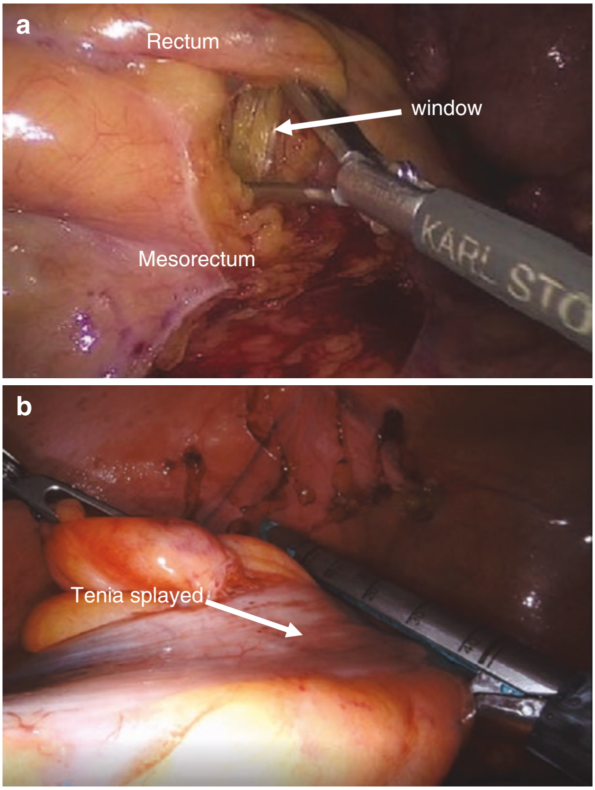

Fig. 28.7 (**a**) Once the site of distal transection has been identified, the mesorectum is divided by creating a window between the posterior wall of the rectum and the mesorectal fat. (**b**) The upper rectum is divided with an endoscopic stapler. Multiple loads may be required; careful attention should be taken to avoid a staggered staple line

the high-pressure zone encountered in the rectosigmoid colon. The upper rectum is isolated by creation of a window between the posterior wall of the rectum and mesentery at the proposed transection site (Fig. 28.7a). Once the bare rectum is appropriately dissected and exposed, division is generally performed with an endoscopic stapling device through the RLQ port (Fig. 28.7b). The appropriate stapling load should be chosen based on the thickness and integrity of the tissue to be divided. It may be required to use additional loads of the stapler in some cases.

Integrity and airtightness of the rectal stump staple line may be tested at this point. The stump is submerged under sterile solution, and gentle insufflation per anus is performed. This can be done with a variety of modalities including rigid proctoscopy, flexible sigmoidoscopy, or bulb syringe insufflation. The former two allow for visualization of the mucosa and staple line. Direct laparoscopic visualization during rectal insufflation should confirm appropriate distension of the stump without air leak (visualized bubbles). If air leak is encountered at this point, two options are available. The first is to introduce the spike of the end-to-end anastomotic circular stapler through the defect. The second option is to resect an additional distal margin incorporating the prior staple line. Air testing may then be repeated.

Extraction and Proximal Colon Transection

Prior to extraction, the distal end of the colon is held with a locking grasper and placed under the location of the anticipated extraction site. Potential extraction sites include extension of the periumbilical incision, creation of a Pfannenstiel incision, or extension of the RLQ incision. When performing a minimally invasive HP, the specimen can be extracted through the marked colostomy site. In a patient who has had prior abdominal operations, using a prior incision may be appropriate. Cosmetically, a Pfannenstiel incision may be preferable and may minimize hernia rates [16]. The incision size will vary between 3 and 6 cm but ultimately is determined by the size of the pathology. Once the abdominal wall is opened appropriately and the peritoneal cavity entered, a wound protector is inserted to protect the skin and soft tissue from contamination during externalization and creation of anastomosis.

Through the wound protector, the distal stapled end of the colon and the proximal mobilized colon and mesentery are extracorporealized. The proximal dissection point is predicated upon a number of factors including inflammation, edema, induration, and perfusion. Appropriate maintenance of vascular supply must be assured to minimize risk of ischemia of the anastomosis. Sharp transection of the marginal artery with resultant pulsatile flow from the proximal end is one method to verify and document appropriate healthy vascular tissue. In the elective setting, newer methods including fluorescence imaging may also be utilized to identify well-perfused tissue prior to transection.

Anastomosis and Intraoperative Leak Testing

A double-stapled technique is often employed during a left or sigmoid colectomy. An end-to-end anastomotic (EEA) stapler height is chosen based on tissue thickness and compliance. Common staple heights range between 3.5 and 4.8 mm staples with optimal closure of 1.5–2 mm in height, respectively. When dealing with the rectum, inflamed or not, the authors typically prefer the latter, green loads. The diameter of the stapler will also vary between 21 and 33 mm and may be selected based on the diameter of the proximal and distal bowel as well as the compliance of the patient's anal tone. Testing of the anastomosis is essential with recent data suggesting the ability to reduce the incidence of missed anastomotic leak [17]. The bowel proximal to the anastomosis is clamped, and an air leak test is performed as described above. Flexible sigmoidoscopy is preferred by the authors as it allows superior visualization of the mucosa and staple line as well as quick resolution of CO_2. If an air leak is encountered, several options exist including direct repair of the anastomotic leak point(s) with or without fecal diversion, takedown and creation of a new anastomosis, or creation of an end colostomy. Choosing the appropriate surgical management of a positive air leak test is dependent on multiple factors and is beyond the scope of this chapter.

Given that risks for anastomotic leak are multifactorial, the absence of a "positive" leak test does not preclude later occurrence of an anastomotic leak. Other factors should be considered when deciding whether to divert including the severity of immunosuppression, worsening hemodynamic instability, difficult dissection or anatomy resulting in increased tension on the anastomosis, malnutrition, and obesity. Routine prophylactic drain placement is not recommended as it was not shown to reduce surgical site infection or anastomotic leaks [18]. Drains should be used selectively in the setting of residual purulent collections or phlegmons or gross feculent spillage.

Considerations During Laparoscopic Hartmann's Procedure

In certain cases, anatomic, physiologic, or disease processes preclude safe or appropriate anastomosis. In those cases, as above, the distal colon or proximal rectum should be transected and divided using an endoscopic stapling device. If there is any potential for future anastomosis, it is helpful to add tags at the staple line using permanent monofilament suture to ease future identification of the rectal stump. When mobilizing the proximal sigmoid and descending colon, all attempts should be made to minimize excess dissection and mobilization more than is necessary to bring out a tension-free colostomy. This will aide in future Hartmann's reversal. Similarly, it may be prudent to have localizing ureteral stents placed at the time of Hartmann's reversal. For more details, please refer to Chap. 20 on Key Steps During Hartmann's Procedures to Facilitate Minimally Invasive Hartman's Reversal.

Pitfalls and Troubleshooting

Fistula/Phlegmon in Diverticular Disease

In the case of fistulas between the colon and other intraperitoneal structures or processes involving phlegmonous collections, care should be taken to minimize concomitant injury/resection (Fig. 28.8a). In general, the authors prefer to place preoperative ureteral catheters (or stents) to help in identification of these structures during dissection. Oftentimes, a combination of lateral-to-medial and medial-to-lateral dissection is required. Initiating the dissection with a medial-to-lateral mobilization close to the takeoff of the IMA may help gain access to the retroperitoneal surface and space between the colon and its mesentery and the sidewall due to decreased acute on chronic inflammatory processes in the central mesentery. This will then help in identification of the ureter and other structures more easily than a primary lateral-to-medial dissection. Dissection may then proceed laterally with anterior retraction of the colon and mesentery. In some cases, it may be helpful to initiate the dissection proximally along the descending colon at an area of decreased inflammatory reaction and proceed caudally. Similarly, rectal mobilization with retrograde dissection can also be a helpful adjunct in mobilizing the colon from the pelvic sidewall and ureter. In certain cases, this dissection and separation of the colon to the sidewall and ureter may require manual disruption with a finger-fracture technique. If significant inflammation and/or abscess are encountered (Fig. 28.8b), in certain cases, anastomosis may be precluded or protected with the use of a diverting loop ileostomy.

Colovesical fistulas may be dissected free without the need for repair. If a small or no bladder defect is visualized, catheter drainage for a few days [8–10] with

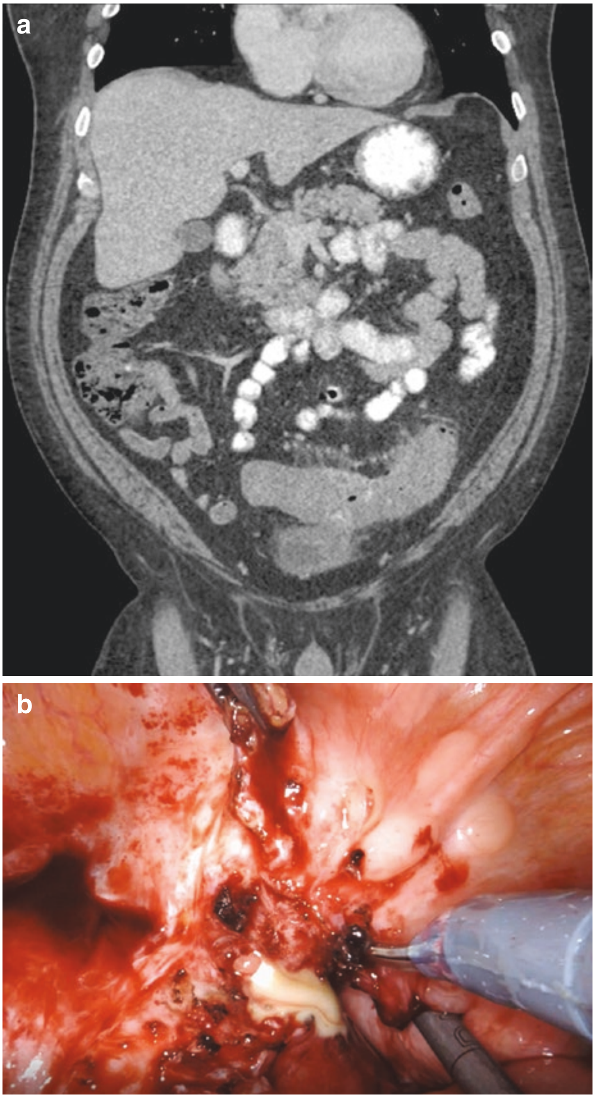

Fig. 28.8 (**a**) CT scan demonstrating a colovesicular fistula secondary to diverticular disease. (**b**) Separating the colon from the bladder reveals a small pericolic abscess

removal predicated upon a negative retrograde cystogram is advised. If a larger bladder defect is uncovered, a two-layer closure of the bladder is advised. Takedown of colovaginal fistulas frequently requires closure of the vaginal defect. Smaller defects may generally heal spontaneously once the inciting phlegmon or fistula has been removed. In these instances, the defect may function as a drain. Larger defects can be closed in a single-layer fashion with an absorbable suture.

In the setting of a prior fistula (colovesical or colovaginal), the anastomosis should be distal to and away from the previously dissected process. Furthermore, a pedicle of healthy and well-vascularized mobilized omentum should be interposed and secured between the anastomosis and the anterior fistula defect to prevent future contamination and fistulous communication with the new anastomosis.

If small bowel is noted to be fistulized with the diseased colon, after takedown of the fistula, either primary repair or small bowel resection is usually indicated. The decision is predicated upon overall condition of the small bowel and size of the fistula.

Obese Patients

Obesity presents a challenge to the surgeon, specifically due to increased mesenteric adiposity and patient weight. To prevent falls and slippage during extremes of positioning required in these cases, extra care must be taken to tape and securely strap the patient to the bed (Fig. 28.9). Obesity can create challenges in identification of landmarks and typical planes that would otherwise be easily accessed (i.e., space over the sacral promontory, around the takeoff of the IMA, retroperitoneal reflections). Additionally, the additional weight of the colon and mesentery may make appropriate retraction and visualization difficult. In these instances, liberal use of additional ports with retracting devices and/or hand assistance may be utilized. It is helpful to differentiate between visceral mesenteric fat and retroperitoneal fat during dissection. Basic knowledge of the typical anatomy and landmarks as well as

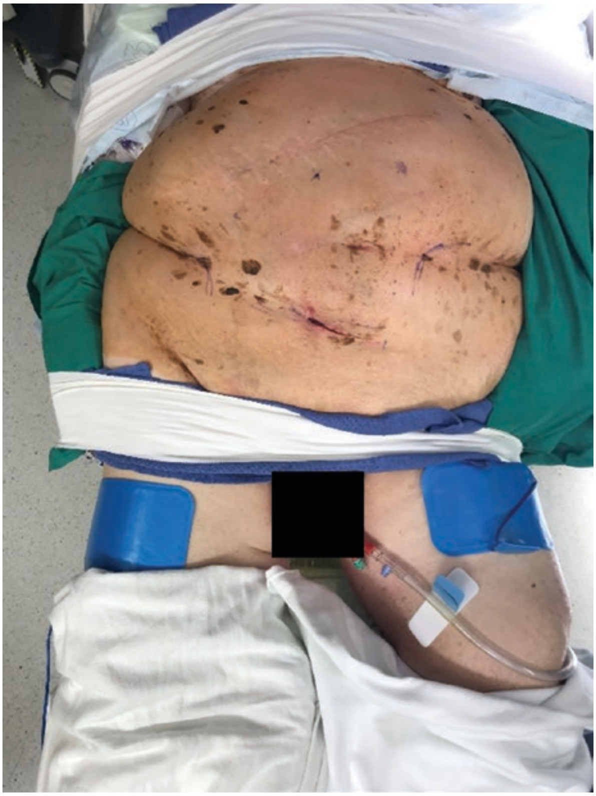

Fig. 28.9 Obesity provides additional challenges with patient positioning, intraoperative exposure, and postoperative fluid management

prior experience in non-obese patient will help the surgeon safely progress during dissection. If the anatomy is not clear or safety becomes a concern, conversion to an open procedure is advised.

Minimally Invasive Non-resectional Approach

Laparoscopic Peritoneal Lavage

Over the past several years, several studies have investigated alternative minimally invasive approaches to mitigate the morbidity of resectional approaches (i.e., Hartmann's procedure) in the setting of Hinchey III diverticulitis. Colectomy and stoma can have profound long-term sequelae, including prolonged ICU stay and permanent stoma. LL has been advocated as an alternative to resectional approaches in carefully selected patients with Hinchey III disease.

Operative Setup

Port Placement

Appropriate port placement is critical in facilitating exposure and anatomic definition. Though no resection is intended, it may be advisable to place the ports accordingly in case colectomy becomes necessary. The authors have advocated a modified 3-"working"-port technique: 5/10 mm umbilical, 5 mm RLQ, and 5 mm RUQ trocars (Fig. 28.2a with omission of the LLQ trocar). The surgeon should be prepared to place an additional LLQ working port for help with manipulation and retraction and also be prepared to upsize the RLQ port to a 10/12 mm port in case of the need to convert to a resectional approach.

Diagnostic Laparoscopy and Identification of Pathology

The decision to proceed with laparoscopic lavage is made early with the presence of frank stool indicating the need for resection. At this stage, gentle retraction of the small bowel should be performed away from the disease process. Care is utilized to avoid inadvertent injury to the small bowel, which if encountered should be promptly repaired or resected. Once the diseased segment and/or abscess is isolated away from the remainder of the abdominal and pelvic contents, suction followed by copious irrigation should be performed. There is no consensus on how much irrigation should be utilized; however, enough volume of sterile fluid should be utilized to minimize the bacterial burden in the peritoneal cavity. Careful inspection of the colon is then performed to identify any additional pathology. In the majority of cases, no demonstrable perforation will be found. In rare cases, a small isolated perforation may be observed and subsequently oversewn. If a large colonic defect is encountered, lavage with oversewing will not be successful, and conversion to a resection procedure is warranted. If a malignancy is suspected, resection is then mandated. Availability of intraoperative flexible sigmoidoscopy is a helpful adjunct to diagnose any malignant process or ongoing perforation. Once lavage is completed, a drain is left in place.

Postoperative Management

Most of patients should then be placed on broad-spectrum antibiotics to treat purulent peritonitis and class IV/infected wounds. Resumption of an oral diet may be instituted if no significant small bowel dilatation was noted (indicative of an impending ileus/obstruction). If successful, most patients will demonstrate a prompt improvement and normalization of their leukocytosis, resolution of abdominal distension, and an ability to tolerate a low-residue diet with return of bowel function. Once all parameters have been achieved on an acceptable pain management regimen, patients can then be discharged with follow-up. If no colonoscopy has been documented within the past 2 years, a full colonoscopy is imperative generally performed to exclude malignancy or other pathology 6 weeks after discharge.

Pitfalls and Troubleshooting

Any operative intervention in the setting of Hinchey III diverticular disease is complex and fraught with risks of further complications. The surgeon must have a strong grasp of the anatomy and experience managing unexpected intraoperative as well as complications. When evaluating the peritoneal cavity, if anatomic landmarks cannot be clearly identified and dissection safely performed, conversion to an open resectional procedure should be contemplated early in the interest of patients' safety.

If the patient's condition fails to improve postoperatively (elevated WBC, prolonged ileus), then the source of persistent intra-abdominal sepsis must be evaluated. If the patient becomes hemodynamically unstable with worsening leukocytosis and/or signs of ongoing sepsis or peritonitis, urgent reoperation is indicated, which may need to be performed open if a minimally invasive approach is not feasible. In the absence of hemodynamic compromise, a CT may be performed 3–4 days postoperatively to evaluate for undrained abscesses which may be drained percutaneously. Management would then proceed as if the patient had Hinchey II disease. If continued disseminated intra-abdominal fluid is noted, there should be a high index of suspicion for continued uncontrolled perforation. Patients may demonstrate ongoing signs of sepsis or a systemic inflammatory response (SIRS). Though additional imaging could be performed (CT or water soluble contrast enema), the general consensus is that patients with ongoing sepsis following LL should undergo resectional therapy (either resection with primary anastomosis and diversion or Hartmann's procedure).

Many cases of LL have been reported as complicated by small bowel fistulas from the laparoscopic attempt at separating and mobilizing the small bowel away from the inflammatory mass. Partial- or full-thickness enterotomy may not have been appreciated at the time of initial lavage. If encountered, primary repair and/or bowel resection should be performed and might require conversion and/or sigmoid resection as well. It is common to see delayed fistulization from the small bowel to another segment of small bowel or colon on follow-up. In these situations, interval resection is necessary. If the patient is otherwise asymptomatic, these procedures can be delayed by at least 6–8 weeks following initial LL and in some instances by 6 months or more.

When performing lavage, it is rarely indicated to mobilize the colon from the left pelvic sidewall. If this becomes necessary, it is imperative that pelvic sidewall structures (i.e., ureter and gonadal vessels) be appropriately identified and preserved. Failure to identify anatomic landmarks during minimally invasive approach is an indication to convert to an open procedure and proceed with a resectional approach as described above.

Outcomes

Resection

Patient with perforated diverticulitis and peritonitis should be considered for early operative intervention to control sepsis. Emergency surgery for perforated diverticulitis is associated with increased morbidity and mortality compared to elective surgery [2]. That being said, studies suggest that the laparoscopic approach for sigmoid resection with or without a stoma decreases overall complications compared to open resections in the emergency setting and should be considered in patients with perforated diverticulitis who are otherwise hemodynamically stable [3, 4, 19].

The optimal treatment strategy for perforated diverticulitis remains controversial. In Hinchey III diverticulitis, sigmoid resection with PRA and proximal diversion has been demonstrated to have similar mortality, lower mobility, and a lower stoma rate at 12 months compared to HP [5, 20–23]. A recent systematic review and meta-analysis demonstrated significantly lower overall mortality in patients with PRA compared with patients with HP [OR (95% CI) = 0.38 (0.24, 0.60), $p < 0.0001$]. Organ/space surgical site infection, reoperation, and ostomy non-reversal rates were significantly lower in PRA [21]. HP remains to the preferred operation in hemodynamically unstable patients with perforated diverticulitis and is associated with acceptable mortality and morbidity.

Laparoscopic Lavage

Numerous groups have performed randomized studies investigating lavage and comparing this modality to HP and resection with PRA and diverting ileostomy. See Tables 28.1 and 28.2. There are three major randomized trials investigating LL for diverticulitis: LOLA/LADIES [24], DILALA [27], and SCANDIV [25].

Acuna and coauthors recently published a Current Status guideline report reviewing six studies, incorporating 626 patients who underwent surgery for perforated diverticulitis. Though early reoperation rates and postoperative mortality were similar in the lavage vs sigmoidectomy group, major complications (Clavien-Dindo > IIIa) were significantly higher after LL group, RR = 1.68 (95% CI, 1.1–2.56) ($p = 0.02$). Similarly, early reoperation rates were slightly higher in the laparoscopic lavage group, RR = 1.93 (95% CI, 1.71–5.22) ($p = 0.20$), as was postoperative

Table 28.1 Primary outcomes of laparoscopic lavage compared to resection – including long-term updates

Study	Author	Year	N	Comparisons	Morbidity rates, RR (95% CI)	Reoperation rates, RR (95% CI)	Mortality, RR (95% CI)	Others
LADIES-LOLA	Vennix [24]	2015	90	LL vs PRA ± DLI vs HP	39% vs 13% ($p = 0.043$) RR 1.83 (95% CI 0.97–3.44) Discontinued early due to increased morbidity	20% vs 7% RR 2.74 (0.79–9.45)	9 vs 14% ($p = 0.43$) 1.83 (0.17–19.41)	
SCANDIV	Schultz [25]	2015	199	LL vs HP or PRA ± DLI	31% vs 26% ($p = 0.53$) RR 1.80 (0.90–3.59)	20% vs 6% ($p = 0.01$) RR 3.78 (1.11–12.84)	14% vs 21% ($p = 0.67$) 0.63 (0.11–3.66)	
SCANDIV	Schultz [26]	2017	199	LL vs HP or PRA ± DLI	34% vs 27% ($p = 32\%$) Deep sepsis: 32% vs 13% ($p = 0.006$)	27% vs 10% ($p = 0.01$)		Stoma 14% vs 42% ($p < 0.001$)
DILALA	Angenete [27]	2016	83	LL vs HP	NS RR 1.23 (0.47–3.19)	13% vs 17% ($p = 0.63$) 0.77 (0.26–2.29)	8% vs 0% 6.47 (0.35–121.17)	Lower operating time ($p < 0.0001$)
DILALA	Thornell [28]	2016	83	LL vs HP	NS	28% vs 63% ($p = 0.004$)	NS	
DILALA	Gerhman [29]	2016	83	LL vs HP				Lower cost −8983€, −19,794€/expected life years
	Angenete [30]	2017	358	LL vs HP or PRA ± I		Reduced OR 0.54 (95% CI, 0.38–0.76)		
DILALA	Kohl [31]	2018	83	LL vs HP		42% vs 68%0.55 (0.36–0.84) $p = 0.012$		Long-term stoma rates: 7% vs 22%
	Shaikh [32]	2017	372	LL vs HP or PRA ± DLI	OR 1.87 (95% CI, 0.68–5.12) ($p = 0.23$)			Increased deep space abscess, OR 4.12 (95% CI, 1.89–8.98) ($p = 0.0004$) Increased risk of percutaneous drainage, OR 5.41 (95% CI, 1.62–18.12) ($p = 0.006$)

LL laparoscopic peritoneal lavage, *HP* Hartmann's procedure, *PRA* primary resection and anastomosis, *DLI* diverting loop ileostomy, *NS* non-significant, *OR* Odd's ratio, *CI* confidence interval, *RR* relative risk

Table 28.2 Long-term secondary outcomes of laparoscopic lavage compared to resection at 12 months

Measures	Trials	Risk ratio (95% CI)	Favoring	P
Major postoperative complication	LOLA, SCANDIV [24, 25]	1.27 (0.89–1.80)	Resection	0.19
Reoperations, including stoma reversal, at 12 months	DILALA, LOLA, SCANDIV	0.67 (0.45–1.02)	Lavage	0.06
Mortality at 12 months	LOLA, DILALA, SCANDIV	0.89 (0.49–1.61)	Lavage	0.70
Patients with stoma at 12 months	DILALA, SCANDIV, LOLA	0.43 (0.22–0.83)	Lavage	0.01

mortality, RR = 1.33 (95% CI, 0.37–4.74) ($p = 0.66$). All three above measured outcomes favored resection over laparoscopic lavage [33].

When evaluating patients undergoing primary sigmoidectomy with PRA and stoma to patients undergoing Hartmann's procedure, similar complication rates (RR = 0.88 (95% CI, 0.49–1.55)) and postoperatively mortality were noted (RR = 0.58 (95% CI, 0.20–1.70)). However, those patients that underwent PRA were more likely to be stoma-free at 1 year compared to those undergoing Hartmann's procedure (RR = 1.40 (95% CI, 1.18–1.67)) and experience fewer major complications related to stoma reversal (RR = 0.26 (95% CI, 0.07–0.89)).

Acuna also performed a meta-analysis attempting to evaluate quality of life and comparing laparoscopic lavage group with the resection group. Due to significant differences in survey instrumentations and variable time points, no appropriate differences nor conclusions could be drawn. Overall, the DILALA trial found similarly poor quality of life at discharge among both groups. The LOLA trial similarly found no differences overall. Lastly, the SCANDIV trial found no significant differences in any of the quality of life measures at 90 days [33].

Beyer-Berjot published a meta-analysis evaluating surgical outcomes following emergency surgery for acute diverticulitis which included LL, open or laparoscopic sigmoidectomy with PRA with or without ostomy. This comprehensive review included 5 guideline papers, 4 meta-analysis, 14 systematic reviews, and 5 randomized controlled trials. Laparoscopic lavage was associated with an increased rate of deep space infections and abscess and a higher rate of unplanned reoperations. When comparing Hartmann's procedure to resection with PRA, the latter had an improved stoma-free rate and improved quality of life [13].

Penna similarly reviewed clinical outcomes between LL and colonic resection for Hinchey III diverticulitis. Based on their analysis, the former had higher rates of intra-abdominal abscesses (RR = 2.85 (95% CI 1.52–5.34), $p = 0.001$), peritonitis (RR = 7.80 (95% CI 2.12–28.69), $p = 0.002$), and increased long-term emergency reoperations (RR = 3.32 (95% CI 1.73–6.38), $p < 0.001$). After stoma reversal, 23% had a stoma after 1 year in the resection group, compared to 7.2% in the lavage group. Of note, 36% of the lavage group eventually underwent elective sigmoid resection [34].

Kohl presented long-term results of the DILALA trial comparing LL to HP. At 2 years, there was a statistically significant increase in the number of reoperations in the Hartmann's group; however, reasons for these secondary operations were similar among the two groups and likely related to the index operation [31].

Though initially advocated as a significant adjunct to minimize morbidity in patients with perforated Hinchey III diverticulitis, an abundance of data from multiple large prospective trials demonstrates that LL is associated with increased major complication rate, increased short-term re-operative rate, and permanent stoma rate when compared to primary resection. In summary, resection with primary anastomosis and diverting ileostomy should be the preferred approach in the management of Hinchey III disease.

In conclusion, when possible, we currently recommend percutaneous drainage of diverticular abscesses which, when successful, can be followed by observation vs definitive resection on an elective basis. In the setting of Hinchey III perforated diverticulitis with purulent peritonitis, the current guidelines and data suggest resection of the diseased sigmoid colon with primary colorectal anastomosis and diverting loop ileostomy in patients that are otherwise stable for an operation is superior to LL and HP. HP remains a viable safe alternative in patients hemodynamically unstable or unfit for creation of an anastomosis. This treatment paradigm results in a significantly lower rate of permanent stoma with lower or equivalent long-term morbidity and mortality when compared to LL (or selective HP). Lavage may be considered in selected Hinchey III patients by surgeons with appropriate expertise and the ability to closely watch for and manage complications. The lower stoma rate should be weighed against the higher risk of postoperative complications and re-intervention encountered after LL.

Conclusions

Emergent laparoscopic colectomy with or without fecal diversion is feasible and safe in carefully selected patients. Current data do not support the routine use of laparoscopic peritoneal lavage for Hinchey III (or IV) diverticulitis. The optimal resectional strategy (open or laparoscopic HP, PRA with or without ileostomy) is determined by multiple factors including surgical experience, patient clinical presentation, and intraoperative findings with consideration of short-term and long-term outcomes and impact on quality of life. The surgical team should frequently reevaluate the intraoperative conditions to ensure the patient's safety is maximized. It is essential to be familiar with various approaches (i.e., medial-to-lateral, lateral-to-medial, superior to inferior, etc.) resulting in optimal exposure as well as safer, quicker, and a more reproducible dissection. This is undoubtedly facilitated by a fundamental understanding of the surgical anatomy, allowing the surgeon the ability to proceed in a safe manner and allow for additional diagnostic and therapeutic maneuvering while maximizing patient quality of life and simultaneously reducing morbidity.

References

1. Abraha I, Binda GA, Montedori A, Arezzo A, Cirocchi R. Laparoscopic versus open resection for sigmoid diverticulitis. Cochrane Database Syst Rev. 2017;(11):CD009277.
2. Alves A, Panis Y, Mantion G, Slim K, Kwiatkowski F, Vicaut E. The AFC score: validation of a 4-item predicting score of postoperative mortality after colorectal resection for cancer or diverticulitis: results of a prospective multicenter study in 1049 patients. Ann Surg. 2007;246(1):91–6.
3. Vennix S, Boersema GS, Buskens CJ, Menon AG, Tanis PJ, Lange JF, et al. Emergency laparoscopic sigmoidectomy for perforated diverticulitis with generalized peritonitis: a systematic review. Dig Surg. 2016;33(1):1–7.
4. Vennix S, Lips DJ, Di Saverio S, van Wagensveld BA, Brokelman WJ, Gerhards MF, et al. Acute laparoscopic and open sigmoidectomy for perforated diverticulitis: a propensity score-matched cohort. Surg Endosc. 2016;30(9):3889–96.
5. Biondo S, Lopez Borao J, Millan M, Kreisler E, Jaurrieta E. Current status of the treatment of acute colonic diverticulitis: a systematic review. Color Dis. 2012;14(1):e1–e11.
6. Hinchey EJ, Schaal PG, Richards GK. Treatment of perforated diverticular disease of the colon. Adv Surg. 1978;12:85–109.
7. Dharmarajan S, Hunt SR, Birnbaum EH, Fleshman JW, Mutch MG. The efficacy of nonoperative management of acute complicated diverticulitis. Dis Colon Rectum. 2011;54(6):663–71.
8. Remzi FH, Oncel M, Hull TL, Strong SA, Lavery IC, Fazio VW. Current indications for blow-hole colostomy:ileostomy procedure. A single center experience. Int J Color Dis. 2003;18(4):361–4.
9. Weber DG, Bendinelli C, Balogh ZJ. Damage control surgery for abdominal emergencies. Br J Surg. 2014;101(1):e109–18.
10. Greco M, Capretti G, Beretta L, Gemma M, Pecorelli N, Braga M. Enhanced recovery program in colorectal surgery: a meta-analysis of randomized controlled trials. World J Surg. 2014;38(6):1531–41.
11. Awotar GK, Guan G, Sun W, Yu H, Zhu M, Cui X, et al. Reviewing the management of obstructive left colon cancer: assessing the feasibility of the one-stage resection and anastomosis after intraoperative colonic irrigation. Clin Colorectal Cancer. 2017;16(2):e89–e103.
12. Person B, Ifargan R, Lachter J, Duek SD, Kluger Y, Assalia A. The impact of preoperative stoma site marking on the incidence of complications, quality of life, and patient's independence. Dis Colon Rectum. 2012;55(7):783–7.
13. Beyer-Berjot L, Maggiori L, Loiseau D, De Korwin JD, Bongiovanni JP, Lesprit P, et al. Emergency surgery in acute diverticulitis: a systematic review. Dis Colon Rectum. 2019; https://doi.org/10.1097/DCR.0000000000001327. [Epub ahead of print].
14. Schmidt S, Ismail T, Puhan MA, Soll C, Breitenstein S. Meta-analysis of surgical strategies in perforated left colonic diverticulitis with generalized peritonitis. Langenbeck's Arch Surg. 2018;403(4):425–33.
15. Belizon A, Sardinha CT, Sher ME. Converted laparoscopic colectomy: what are the consequences? Surg Endosc. 2006;20(6):947–51.
16. DeSouza A, Domajnko B, Park J, Marecik S, Prasad L, Abcarian H. Incisional hernia, midline versus low transverse incision: what is the ideal incision for specimen extraction and hand-assisted laparoscopy? Surg Endosc. 2011;25(4):1031–6.
17. Ricciardi R, Roberts PL, Marcello PW, Hall JF, Read TE, Schoetz DJ. Anastomotic leak testing after colorectal resection: what are the data? Arch Surg. 2009;144(5):407–11; discussion 11–2.
18. Reiffel AJ, Barie PS, Spector JA. A multi-disciplinary review of the potential association between closed-suction drains and surgical site infection. Surg Infect. 2013;14(3):244–69.
19. Turley RS, Barbas AS, Lidsky ME, Mantyh CR, Migaly J, Scarborough JE. Laparoscopic versus open Hartmann procedure for the emergency treatment of diverticulitis: a propensity-matched analysis. Dis Colon Rectum. 2013;56(1):72–82.

20. Cirocchi R, Trastulli S, Desiderio J, Listorti C, Boselli C, Parisi A, et al. Treatment of Hinchey stage III-IV diverticulitis: a systematic review and meta-analysis. Int J Color Dis. 2013;28(4):447–57.
21. Gachabayov M, Oberkofler CE, Tuech JJ, Hahnloser D, Bergamaschi R. Resection with primary anastomosis vs nonrestorative resection for perforated diverticulitis with peritonitis: a systematic review and meta-analysis. Color Dis. 2018;20(9):753–70.
22. Oberkofler CE, Rickenbacher A, Raptis DA, Lehmann K, Villiger P, Buchli C, et al. A multicenter randomized clinical trial of primary anastomosis or Hartmann's procedure for perforated left colonic diverticulitis with purulent or fecal peritonitis. Ann Surg. 2012;256(5):819–26; discussion 26–7.
23. Toro A, Mannino M, Reale G, Cappello G, Di Carlo I. Primary anastomosis vs Hartmann procedure in acute complicated diverticulitis. Evolution over the last twenty years. Chirurgia (Bucur). 2012;107(5):598–604.
24. Vennix S, Musters GD, Mulder IM, Swank HA, Consten EC, Belgers EH, et al. Laparoscopic peritoneal lavage or sigmoidectomy for perforated diverticulitis with purulent peritonitis: a multicenter, parallel-group, randomized, open-label trial. Lancet. 2015;386(10000):1269–77.
25. Schultz JK, Yaqub S, Wallon C, Blecic L, Forsmo HM, Folkesson J, et al. Laparoscopic lavage vs primary resection for acute perforated diverticulitis: the SCANDIV randomized clinical trial. JAMA. 2015;314(13):1364–75.
26. Schultz JK, Wallon C, Blecic L, Forsmo HM, Folkesson J, Buchwald P, et al. One-year results of the SCANDIV randomized clinical trial of laparoscopic lavage versus primary resection for acute perforated diverticulitis. Br J Surg. 2017;104(10):1382–92.
27. Angenete E, Thornell A, Burcharth J, Pommergaard HC, Skullman S, Bisgaard T, et al. Laparoscopic lavage is feasible and safe for the treatment of perforated diverticulitis with purulent peritonitis: the first results from the randomized controlled trial DILALA. Ann Surg. 2016;263(1):117–22.
28. Thornell A, Angenete E, Gonzales E, Heath J, Jess P, Lackberg Z, et al. Treatment of acute diverticulitis laparoscopic lavage vs. resection (DILALA): study protocol for a randomized controlled trial. Trials. 2011;12:186.
29. Gehrman J, Angenete E, Bjorholt I, Bock D, Rosenberg J, Haglind E. Health economic analysis of laparoscopic lavage versus Hartmann's procedure for diverticulitis in the randomized DILALA trial. Br J Surg. 2016;103(11):1539–47.
30. Angenete E, Bock D, Rosenberg J, Haglind E. Laparoscopic lavage is superior to colon resection for perforated purulent diverticulitis-a meta-analysis. Int J Color Dis. 2017;32(2):163–9.
31. Kohl A, Rosenberg J, Bock D, Bisgaard T, Skullman S, Thornell A, et al. Two-year results of the randomized clinical trial DILALA comparing laparoscopic lavage with resection as treatment for perforated diverticulitis. Br J Surg. 2018;105(9):1128–34.
32. Shaikh FM, Stewart PM, Walsh SR, Davies RJ. Laparoscopic peritoneal lavage or surgical resection for acute perforated sigmoid diverticulitis: a systematic review and meta-analysis. Int J Surg. 2017;38:130–7.
33. Acuna SA, Wood T, Chesney TR, Dossa F, Wexner SD, Quereshy FA, et al. Operative strategies for perforated diverticulitis: a systematic review and meta-analysis. Dis Colon Rectum. 2018;61(12):1442–53.
34. Penna M, Markar SR, Mackenzie H, Hompes R, Cunningham C. Laparoscopic lavage versus primary resection for acute perforated diverticulitis: review and meta-analysis. Ann Surg. 2018;267(2):252–8.