JAMA Surgery | Review

# Management of Diverticulitis
## A Review

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**IMPORTANCE** Care of patients with diverticulitis is undergoing a paradigm shift. This narrative review summarizes the current evidence for left-sided uncomplicated and complicated diverticulitis. The latest pathophysiology, advances in diagnosis, and prevention strategies are also reviewed.

**OBSERVATIONS** Treatment is moving to the outpatient setting, physicians are forgoing antibiotics for uncomplicated disease, and the decision for elective surgery for diverticulitis has become preference sensitive. Furthermore, the most current data guiding surgical management of diverticulitis include the adoption of new minimally invasive and robot-assisted techniques.

**CONCLUSIONS AND RELEVANCE** This review provides an updated summary of the best practices in the management of diverticulitis to guide colorectal and general surgeons in their treatment of patients with this common disease.

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Diverticulitis is growing in prevalence and imposes a large clinical and economic burden in industrialized nations.[1,2] Increasing prevalence is matched by increasing emergency department visits, cost of care, and surgery for diverticulitis.[3] Each year, the disease is responsible for approximately 500 000 hospital admissions in the US and costs nearly $9 billion overall to treat.[4] Fortunately, our understanding of the pathophysiology and management of diverticular disease is evolving to meet the clinical burden.

Care of patients with diverticular disease is shifting to the outpatient setting, and fewer patients are undergoing emergency bowel surgery, with a 33.7% decrease in surgical intervention observed after emergency department visits between 2006 and 2013.[3] Elective surgery is no longer indicated for all patients after 1 episode of acute complicated diverticulitis.[5] For patients who require surgery for diverticulitis, there has been a rise in the use of minimally invasive surgical approaches.[6] The combination of a rapidly evolving landscape and increasingly common problem necessitates an evolving and adaptive approach to treatment. In this article, we review the latest in treatment for left-sided diverticulitis.

For purposes of uniformity of definitions, we define the types of diverticulitis. Acute uncomplicated diverticulitis is defined as localized inflammation to diverticula of the colon without abscess or perforation and may include thickening of the colon wall or increased density of pericolic fat on computed tomography (CT) imaging.[7] Complicated acute diverticulitis is defined as acute diverticulitis that has progressed to phlegmon, abscess, or perforation. The Hinchey classification and modified Hinchey classification are most commonly used to stratify acute complicated diverticulitis by severity and are used by many of the studies included in this review (**Table 1**). The modified Hinchey classification was developed after the popularization of CT imaging for the diagnosis of diverticulitis and not only includes uncomplicated diverticulitis, which Hinchey did not, but also expands the definitions of stage I and II disease based on imaging findings.[8]

## Presentation and Diagnosis of Acute Diverticulitis

The classic presentation of acute diverticulitis includes left lower quadrant pain and tenderness accompanied by leukocytosis. Complete blood cell count and urinalysis should be obtained as part of the initial workup. Differential diagnosis includes constipation, irritable bowel syndrome, inflammatory bowel disease, appendicitis, neoplasia, kidney stones, urinary tract infection, bowel obstruction, gynecologic disease, and others. History should probe for fecaluria, pyuria, pneumaturia, and stool per vagina as these raise concern for colovaginal or colovesical fistula.

Currently, CT imaging is standard of care to diagnose diverticulitis and tailor treatment.[9] Computed tomography findings associated with diverticulitis may include colonic wall thickening, fat stranding, abscess, fistula, and extraluminal gas and fluid. The severity of disease on CT imaging correlates short term with risk of failure of nonoperative management and long term with recurrence, persistence of symptoms, and development of a colonic stricture and fistula.[10-12] In patients for whom CT imaging is contraindicated, ultrasound can help to rule out other causes of pelvic pain but should not be used primarily for the diagnosis of diverticular disease.[13,14] Magnetic resonance imaging can be useful in patients for whom CT is contraindicated and suspicion of diverticular disease is high.[15] However, magnetic resonance imaging is limited for the evaluation of extraluminal air.[13]

There is a burgeoning field of research exploring the role of C-reactive protein, procalcitonin, and fecal calprotectin in diagnosing and grading the severity of diverticular disease.[16-18] However, the American Society of Colon and Rectal Surgeons (ASCRS) currently does not recommend depending on these emerging diagnostic adjuncts for the diagnosis and management of acute diverticulitis.[5]

## Preventing Acute Diverticulitis

The etiology of diverticulosis is still unclear but may be a combination of diet, genetics, inflammation, lifestyle, and the microbiome.[19,20] Of these factors, diet and lifestyle have been most reliably studied. In a large prospective cohort study of men from the Health Professionals Follow-Up Study, a "prudent" diet high in fruits, vegetables, and whole grains was associated with a lower risk of diverticulitis than a typical Western diet.[21] Liu et al[22] showed a similar pattern in 907 incident cases of diverticulitis, identifying the following factors associated with a decreased incidence of diverticulitis: average red meat intake (less than 51 g per day), dietary fiber intake in the top 40% of the cohort (approximately 23 g per day), approximately 2 hours of exercise weekly, normal body mass index, and being a never-smoker. These data are, of course, limited by the study's narrow inclusion criteria of men.

A recent article from the Physical Activity and Aging Study showed that higher cardiorespiratory fitness in conjunction with lower body mass index was correlated with a reduced odds of diverticulitis and that obesity was associated with an increased prevalence of diverticulitis, even in patients with high cardiorespiratory fitness.[23] The ongoing IMPEDE (Investigation of Medical Management to Prevent Episodes of Diverticulitis) randomized clinical trial (RCT) is assigning patients with a history of diverticulitis to either a Mediterranean-style diet or standardized guidance on fiber intake to assess willingness to adhere to a Mediterranean diet. The purpose of this study is to determine whether reducing inflammation using a Mediterranean diet may prevent acute diverticulitis. In the current phase of IMPEDE, the investigators are measuring inflammatory biomarkers related to diverticulitis and addressing barriers to adherence and randomization to a Mediterranean diet in order to prepare for a large-scale trial on the association between diet modification and recurrence of diverticulitis.[24] In addition, there are longstanding but low-quality data on the association between low fiber intake and acute diverticulitis.[25-27] While evidence lacks robustness at this time for lifestyle interventions, including dietary changes, exercise, and fiber intake, these are low-cost and health-promoting interventions that are unlikely to have negative consequences for patients.

There is a burgeoning field of study examining how the microbiome shapes the development of diverticulitis and the severity of diverticular disease. A 2023 study, the largest of its kind, used RNA sequencing to compare harvested diseased and nondiseased tissue from the surgical resections of 48 patients with recurrent, uncomplicated diverticulitis and 35 patients with complicated acute diverticulitis.[28] The results showed that complicated diverticulitis tissue samples had increased sulfur-reducing bacteria compared with adjacent normal-appearing tissue and tissue samples from uncomplicated diverticulitis. Another contemporary review on the microbiome and its association with diverticulitis (which did not include the aforementioned study) delineated the limitations of the current data and use of available evidence and proposed a link between fiber intake and the microbiome in the development of diverticulitis.[29] Because certain bacteria can only digest certain types of fiber, increased fiber intake creates competitive niches for certain bacteria that may be protective against disease states, such as diverticulitis. Conversely, a lack of fermentable fiber in the colon may promote bacteria that use colonic mucin as a food source, leading to colonic wall thinning, which could affect the development of diverticular disease more broadly.

Table 1. Modified Hinchey Classification

| Stage | Clinical finding |
|---|---|
| 0 | Mild clinical diverticulitis |
| Ia | Confined pericolonic inflammation or phlegmon |
| Ib | Pericolonic or mesocolic abscess |
| II | Pelvic, intra-abdominal, or retroperitoneal abscess |
| III | Generalized purulent peritonitis |
| IV | Generalized feculent peritonitis |

## Management of Acute Uncomplicated Diverticulitis

There is a growing body of evidence that antibiotics are not necessary for the treatment of uncomplicated diverticulitis. In 2021, the DINAMO (Efficacy and Safety of Nonantibiotic Outpatient Treatment in Mild Acute Diverticulitis) trial was performed on this topic in the outpatient setting.[30] This multicenter, randomized, open-label noninferiority trial randomized 480 patients to outpatient treatment for 7 days with amoxicillin and clavulanic acid (classic treatment) or with ibuprofen and acetaminophen (symptomatic treatment). There was no significant difference in hospitalizations or further emergency department visits. In fact, pain control was improved in the symptomatic treatment group compared with the antibiotic group. In this study, treatment failure was defined as poor symptom control prompting a return to the emergency department. If symptomatic control could not be achieved within 24 hours without antibiotics but the patient was otherwise clinically stable, a course of amoxicillin and clavulanic acid was prescribed, and the patient was discharged. If analytic worsening was observed, such as worsening leukocytosis and/or C-reactive protein or radiologic worsening, admission was recommended for intravenous antibiotics.

Garfinkle et al[31] published a noninferiority meta-analysis of 9 studies based on Delphi consensus and patient input, concluding that observational therapy was noninferior to antibiotics for acute uncomplicated diverticulitis. Interestingly, patients were willing to accept a longer time to recovery and increased risk of developing persistent or complicated diverticulitis to forgo antibiotics. A response to this study suggested that if every person who presented to the emergency department with diverticulitis each year received antibiotic treatment, it would cost $68 700 000, which does not take into account the increasingly prevalent expense of antibiotic resistance. Forgoing antibiotics has the potential for substantial cost-savings for the health care system.[32] An updated Cochrane systematic review endorsed treatment for diverticulitis

without antibiotics as a feasible option, but the authors cautioned that the total body of evidence taken together is of low quality.[33]

Despite research suggesting that antibiotic treatment is not necessary in healthy patients with acute uncomplicated diverticulitis, a recent Society of Gastrointestinal and Endoscopic Surgeons survey showed that only 26% of surgeon respondents had integrated this recommendation into their practice, and 50% reported that these new data were unlikely to change their practice.[34] Though uptake has been slower in the US than in Europe, it may be safe to treat healthy patients with acute uncomplicated diverticulitis as outpatients without antibiotics. Antibiotics are still recommended by the ASCRS guidelines for patients with substantial comorbidities, signs of systemic infection, or immunosuppression.[5]

## Nonoperative Management of Complicated Diverticulitis

Complicated diverticulitis is defined as diverticulitis with abscess formation and occurs in up to 40% of patients who present with acute diverticulitis.[35-37] Approximately 80% of patients with complicated diverticulitis can be successfully treated nonoperatively, including antibiotics with or without percutaneous drainage. Percutaneous drainage reduces the recurrence of abscess and should be considered in patients with abscesses greater than 3 cm.[31,35,38-40] Approximately 34% of patients with large abscesses who do not receive percutaneous drainage experience nonoperative treatment failure.[38,39] Therefore, patients who cannot undergo safe percutaneous draining or who do not respond to antibiotics should be considered for surgical treatment.

Patients who are successfully treated nonoperatively for diverticulitis should undergo colonoscopy. The risk of malignant neoplasm in patients with complicated diverticulitis is as high as 11% compared with less than 1% for those with uncomplicated diverticulitis.[41] While dogma dictates that colonoscopy be performed 6 weeks following complicated diverticulitis to reduce the likelihood of perforation during the procedure, there is a deficit of rigorous evidence to support this recommendation.[42] Small studies over the past 20 years suggested that early in-hospital colonoscopy may be safe for select patients without free or pericolic air and for those with a protracted, unresolved course of diverticulitis that would benefit from further investigation.[43-45]

## Elective Surgery for Diverticulitis

There is much debate about interval colectomy following successful nonoperative treatment of diverticulitis. Between 2014 and 2020, the ASCRS updated its practice recommendations in 2 major ways. First, rather than advising that all patients receive interval colectomy after acute uncomplicated diverticulitis, the guidelines now suggest that this option should be considered and weighed against the patient's risk of surgery. Second, the ASCRS recommends considering elective surgery for any episode of acute complicated diverticulitis, not just episodes involving large or pelvic abscesses. In disease complicated by fistula, obstruction, or stricture, the ASCRS continues to recommend interval elective colectomy.[5]

On the heels of the ASCRS guideline updates, there has been a turn toward shared decision-making between surgeon and patient when discussing elective surgery for diverticulitis, with an emphasis on value-aligned care. Born out of this shift is a newer body of research focusing on health-related quality of life in patients with diverticulitis. Results from the recent prospective observational survey study DEBUT (Diverticulitis Evaluation of Burden and Trajectory) showed that patients and surgeons often consider different elements of quality of life important when weighing the risks of surgery.[46] The results showed that patients had concerns that surgeons did not prioritize caregiving, coupled with anxiety about permanent damage to their bodies. This discordance is important to understand when framing the risks and benefits of surgical management of diverticulitis. In a recent qualitative study, semi-structured interviews with surgeons highlighted the complexity of decision-making in elective surgery for diverticulitis and the various factors different surgeons prioritize, including considerations about the patient's preferences, insurance, social factors, and medical history.[47] Of note, these 2 studies did not stratify by complicated and uncomplicated diverticulitis when recruiting patients.

Data can bolster these shared decision-making conversations with patients (**Table 2**).[48-54] The recent LASER (Laparoscopic Elective Sigmoid Resection Following Diverticulitis) RCT compared laparoscopic elective sigmoid resection with conservative treatment on quality-of-life metrics in patients with recurrent, complicated, or persistent painful diverticulitis.[48] In the 85 adults included in the analyses, the Gastrointestinal Quality of Life Index score improved 11.8 points in patients who received sigmoid resection vs 0.2 points in patients who were treated conservatively. Only 4 of the 85 patients experienced major complications. This study suggested improved quality of life, despite the risk of major complications, in elective laparoscopic sigmoid resection for recurrent diverticulitis. The ongoing COSMID (Comparison of Surgery and Medicine on the Impact of Diverticulitis) trial is randomizing patients with quality-of-life–limiting diverticular disease to elective sigmoid colectomy or best medical management.[55] The study hypothesizes that patients in the elective surgery group will have improved quality-of-life outcomes. The study is expected to be completed in 2026 and has the potential to significantly affect surgical decision-making for diverticulitis. Ultimately, the decision to perform interval colectomy after 1 episode of acute diverticulitis should be tailored to the individual patient, the details of their disease process and symptom severity, and their medical and social milieu.

## Emergency Surgery for Diverticulitis

Up to 32% of patients hospitalized with diverticulitis require emergency surgery.[26,56] Indications for emergency surgery include diffuse peritonitis and hemodynamic instability secondary to purulent or feculent peritonitis. Patients who require emergency surgery for diverticulitis are at high risk of mortality. A National Surgical Quality Improvement Project (NSQIP) study that evaluated complications after emergency colectomy for diverticulitis in 2214 patients showed a 30-day mortality rate of 5.1%.[56] Factors associated with mortality included age greater than 80 years, American Society of Anesthesiologists class 4 or 5, serum creatinine greater than 1.2 mg/dL, and albumin less than 2.5 g/dL. Patients with 2, 3, or 4 of these

Table 2. Recent Randomized Clinical Trials in Surgery for Diverticulitis

| Study name, location | Year | Condition | Groups, No. of participants | Results |
|---|---|---|---|---|
| LASER, Finland[48] | 2021 | Recurrent diverticulitis, complicated diverticulitis, and persistent pain after diverticulitis | Laparoscopic SR, 37; conservative treatment, 35 | Quality of life improved in the resection group, with 10% risk of major complication (difference in GIQLI score at 6 mo was 11.96 points higher in resection group). |
| DIRECT, Netherlands[49] | 2017 | Recurrent diverticulitis and persistent pain after diverticulitis | Laparoscopic SR, 53; conservative treatment, 56 | Quality of life improved in the resection group, with a 15% rate of anastomotic leakage (GIQLI score 114.4 points in the resection group vs 100 in the control group). Study was prematurely terminated due to difficulty in recruitment. |
| DILALA, Sweden and Denmark[50] | 2016 and 2018 | Perforated diverticulitis with purulent diverticulitis | Laparoscopic lavage, 39; HP, 36 | Up to 12 wk postoperatively, morbidity and mortality did not differ. Shorter operating time and hospital stay occurred in laparoscopic lavage group. At 2 y, the laparoscopic lavage group had a 45% reduced risk of undergoing ≥1 operation and had fewer operations than the HP group. |
| SCANDIV, Sweden and Norway[51,52] | 2015 | Suspected perforated diverticulitis undergoing emergency surgery | Laparoscopic lavage, 101; SR, 98 | Laparoscopic lavage was associated with more deep infections but fewer surgical site infections and more unplanned reoperations. Including stoma reversals, a similar proportion of patients required a secondary operation. Stoma rate at 1 y was lower in the laparoscopic lavage group. |
| Ladies, DIVA; Belgium, Italy, Netherlands[53] | 2019 | Perforated diverticulitis with fecal peritonitis | HP, 68; primary anastomosis, 65 | Stoma-free survival at 12 mo improved in the primary anastomosis group (94.6% vs 71.7%), with no differences in short-term morbidity and mortality. |
| Ladies, LOLA; Belgium, Italy, Netherlands[54] | 2015 | Perforated diverticulitis with purulent peritonitis | Laparoscopic lavage, 45; SR, 42 | Laparoscopic lavage was not superior to SR. Study was prematurely terminated secondary to increased event rate in the lavage group. |

Abbreviations: DILALA, Diverticulitis Laparoscopic Lavage vs Resection; DIRECT, Diverticulitis Recurrences or Continuing Symptoms; DIVA, Perforated Diverticulitis vs Sigmoid Resection With or Without Anastomosis; GIQLI, Gastrointestinal Quality of Life Index; HP, Hartmann procedure; Ladies, Laparoscopic Peritoneal Lavage or Resection for Generalized Peritonitis for Perforated Diverticulitis; LASER, Laparoscopic Elective Sigmoid Resection Following Diverticulitis; LOLA, Laparoscopic Lavage; SCANDIV, Scandinavian Diverticulitis Trial; SR, sigmoid resection.

factors had a 30-day mortality rate of 10%, 22.9%, and 53.4%, respectively. Surgery may also be indicated in patients with a more indolent course, such as those who do not improve with medical therapy, who have refractory pain, or who cannot tolerate enteral nutrition. Operative management in these circumstances is highly tailored to the patient and depends on clinical judgment.

Historically, a Hartmann stump and end colostomy were standard of care, but there is a growing body of evidence suggesting that resection with primary anastomosis improves morbidity and mortality in certain patients. Multiple RCTs have demonstrated that primary anastomosis with or without diverting loop ileostomy is overall less morbid than a Hartmann procedure because of significant added morbidity secondary to the stoma reversal.[57-59] The DIVA (Perforated Diverticulitis vs Sigmoid Resection With or Without Anastomosis) arm of the Ladies (Laparoscopic Peritoneal Lavage or Resection for Generalized Peritonitis for Perforated Diverticulitis) trial randomized 133 patients with Hinchey III or IV disease to resection and primary anastomosis vs Hartmann procedure and found that 12-month stoma-free survival was higher in patients undergoing primary anastomosis without a significant effect on morbidity or mortality.[53] The caveat to this trial is that patients with preoperative shock and inotropic pressor requirement, which may compromise a primary anastomosis, were excluded from the trial. A meta-analysis of 6 RCTs, which did not include the DIVA arm of the Ladies trial, found that the Hartmann procedure had a higher rate of postoperative complications than primary anastomosis, which was primarily due to complications with stoma reversal. Similar to the DIVA findings, patients who underwent primary resection and anastomosis were more likely to be stoma free at 12 months compared with the Hartmann procedure.[60]

Despite evidence suggesting that sigmoid colectomy and primary anastomosis (with or without diversion) has improved outcomes compared with the Hartmann procedure, adoption has been low overall. A national database study comparing the use of primary anastomosis with diversion to the Hartmann procedure in emergency surgery for diverticulitis showed that while there was a modest increase in use of primary anastomosis over the study period, less than 90% of patients still underwent the Hartmann procedure.[61] In this cohort, there was a higher rate of complications associated with primary anastomosis and diverting loop ileostomy. A subsequent study using a New York State all-payer sample database analyzed 10 600 patients who underwent emergency surgery for diverticulitis over a 15-year period and found a 2-fold greater risk of postoperative mortality when noncolorectal-trained surgeons performed a primary anastomosis vs the Hartmann procedure.[62] In this study, colorectal surgeons performed only 6% of the total operations. Findings from this single-state retrospective study suggested that the type of surgeon and hospital setting may influence the appropriateness of restoring bowel continuity.

There is less robust evidence to delineate when a diverting loop ileostomy is indicated in addition to sigmoid resection and primary anastomosis. The rationale for a diverting loop ileostomy in this population is to minimize the clinical consequences of an anastomotic leak because a column of stool is not passing through the anastomosis. Most of the studies are limited by small sample size. One 2013 NSQIP study compared patients who underwent a Hartmann procedure, primary anastomosis, or primary anastomosis with proximal diversion.[63] Though the authors found no difference in morbidity or mortality among these groups, the number of patients who re-

ceived proximal diversion was too small to effectively power the study. The DIVERTI (Primary vs Secondary Anastomosis for Hinchey Stage III-IV Diverticulitis) prospective multicenter RCT analyzed a subgroup of 15 patients undergoing a primary anastomosis without an ileostomy.[58] These patients reported overall lower morbidity and serious complications compared with those with primary anastomosis with an ileostomy. The Ladies trial also analyzed a subgroup of patients who underwent primary anastomosis with and without ileostomy and found no difference in overall morbidity and mortality but a shorter length of stay in patients without an ileostomy.[53] Again, the subgroups were small and, thus, underpowered in all of these analyses. The decision for ileostomy creation should be made by the surgeon based on case- and patient-specific factors until more robust evidence is available.

## Minimally Invasive Techniques

Colorectal surgery has incorporated minimally invasive techniques, such as laparoscopic and robotic surgery, into its arsenal for both elective and emergency surgeries. Diverticulitis can present an increased technical challenge for surgeons secondary to the inflammatory pathophysiology of the disease. The sigmoid often presents thickened and inflamed and may be adhered to adjacent organs.[64,65] However, for healthy patients who are hemodynamically stable and who have not had extensive abdominal surgery, minimally invasive approaches are safe in the hands of an experienced surgeon.

The Sigma trial was a large, multicenter, double-blind RCT comparing outcomes between laparoscopic and open sigmoid resection for diverticulitis.[66] Patient inclusion criteria for elective sigmoid resection were 2 or more prior episodes of acute diverticulitis with or without abscess presenting at least 3 months after the last diverticulitis episode. The laparoscopic approach demonstrated decreased postoperative complications and pain and a shorter hospital length of stay with improved quality of life. In the long-term follow-up assessment study, the laparoscopic group showed decreased development of hernias, adhesive small-bowel obstruction, anastomotic stricture, enterocutaneous fistula, and recurrence of disease.[67]

A number of retrospective studies have evaluated laparoscopic vs open sigmoid resection for perforated diverticulitis in the acute setting and showed the feasibility of the minimally invasive approach even in the emergent or urgent setting.[68,69] In an NSQIP propensity score–weighted analysis, the authors found that the laparoscopic approach had significantly better outcomes than open and laparoscopic converted to open cases, including fewer surgical site infections, unplanned intubation, and acute kidney failure. However, the laparoscopic group had longer operating times.[70] A single-center retrospective study compared laparoscopic sigmoid resection for Hinchey III diverticulitis to elective laparoscopic sigmoid resection for recurrent diverticulitis and found similar morbidity and anastomotic leak rates between groups, suggesting the safety of the laparoscopic approach for acute complicated diverticulitis.[71] However, surgeons at this institution were highly trained in laparoscopic surgery, so the results are only generalizable to hospitals that have highly skilled laparoscopic surgeons. A recent propensity score–matched study evaluated inpatient opioid use among patients undergoing elective sigmoid resection for acute diverticulitis.[72] Unsurprisingly, the authors found that the minimally invasive approach reduced postoperative parenteral opioid use and decreased time to starting oral opioids compared with open surgery. The major issue with these retrospective studies is selection bias, as the open technique may be reserved for sicker patients or patients with more severe disease.

In recent years, the robotic approach has been gaining traction for use in emergency and elective surgery for diverticular disease. Robotic surgery offers 3-dimensional visualization of the operative field, improved range of motion compared with laparoscopic instruments, and immunofluorescence to better visualize the ureters.[6,73] These tools may be particularly useful in surgery for diverticulitis, where the operative field may be scarred, inflamed, and indurated. A recent retrospective study compared conversion to open surgical rates between laparoscopic and robotic surgical techniques in elective sigmoid resection for diverticular disease.[74] The authors found higher conversion to open surgery with the laparoscopic (13.6%) vs robotic-assisted (8.3%) approach. A study of 6880 nonelective colectomies for acute diverticulitis (laparoscopic, 6583; robotic, 297) found no difference in mortality, anastomotic leak, surgical site infection, reoperation, readmission, or length of stay.[75] However, there was a large discrepancy in the size of each group, which reduces overall confidence in the generalizability of the findings. A recent review on robotic surgery in acute care colorectal surgery cautioned that the largest barrier to emergent robotic surgery is after-hours access to the robot and the availability of a trained robotic team.[76] The dissemination of emergency robotic surgery may be mitigated by issues of operating room staffing. However, comparative clinical outcomes of laparoscopy makes the robotic-assisted approach a promising way to alleviate some of the technical challenges of minimally invasive surgery for diverticular disease.

## Laparoscopic Lavage and Damage Control Procedures

Laparoscopic lavage has been proposed as a potential alternative to sigmoid resection in purulent or feculent perforated diverticulitis. The idea is to avoid the morbidity from a sigmoid resection in a patient with a potentially hostile abdomen while removing the fecal matter or purulent fluid. Later, the patient can theoretically undergo elective sigmoid resection. However, the short-term RCT data comparing laparoscopic lavage with sigmoid resection have shown increased postoperative complications in the lavage group.[50,51,54,77] A meta-analysis estimated that for every 9 patients treated with laparoscopic lavage, 1 additional complication would have been avoided by bowel resection.[60]

Long-term results for laparoscopic lavage were recently released from SCANDIV (Scandinavian Diverticulitis Trial) and are more promising.[52] The 5-year outcomes of SCANDIV, which compared sigmoid resection with laparoscopic lavage, demonstrated that in the long term, the laparoscopic lavage and sigmoid resection groups had similar complication rates, though the short-term results showed increased complications in the laparoscopic lavage group. These results were posited to be due to hernia and wound dehiscence complications in the resection group.[78] More research is required to delineate the type of patient, hospital setting, and surgeon com-

bination that may benefit from laparoscopic lavage over sigmoid resection.[79]

While laparoscopic lavage alone may be limited in utility, a recent systematic review analyzed 8 different retrospective studies examining damage control surgery for majority Hinchey III and IV diverticulitis.[80] Damage control surgery includes 2 stages: (1) emergency resection of the diseased colon (not always a complete sigmoid resection) leaving the bowel in discontinuity, lavage, and vacuum-assisted temporary abdominal closure and (2) second-look surgery after 24 to 48 hours with definitive reconstruction and colorectal anastomosis (with or without diverting loop ileostomy) or Hartmann procedure. Of 256 patients included in the review, colorectal anastomosis was successful in 73% on the second-look surgery. More than one-half of the patients were discharged without a stoma. Using a combined approach of lavage with sigmoid resection may be a promising way to shorten the operative time in unstable and critically ill patients, using the benefits of lavage while performing a definitive operation.

## Special Populations: Immunosuppression

As of 2020, more than 5% of the US population is immunosuppressed for any reason.[81] With the pharmacologic advances of biologic medications, this percentage is expected to increase in the coming decades. In 2021, a systematic review and meta-analysis was conducted that included 11 studies with 2977 patients with immunosuppression undergoing surgery for diverticular disease.[82] Compared with immunocompetent patients, immunocompromised patients had a significantly higher risk of mortality after emergent surgery but not elective surgery. Unsurprisingly, however, immunosuppressed patients had a higher rate of surgical complications compared with immunocompetent patients undergoing elective surgery. Given the dearth of high-quality data to drive decision-making in these patients, the decision of when to operate on this high-risk population should be tailored to the individual patient and discussed with them prior to surgery. The increased mortality associated with emergency surgery should be weighed against the potential complications of an elective case.

## Discussion

Our understanding of the management of diverticulitis is undergoing a paradigm shift. Antibiotics are no longer required to be used routinely in uncomplicated disease. Complicated disease is increasingly managed via percutaneous methods, and the decision for interval sigmoid resection has become preference sensitive. Minimally invasive techniques are more often used. Burgeoning data on the link between the microbiome and colonic disease could change the world of colon surgery more broadly. There are many opportunities for further study to better define the use of diverting loop ileostomy, for example, and to elucidate which patients and circumstances would benefit most from minimally invasive approaches.

### Limitations

This narrative review has several important limitations. First, it is limited to left-sided diverticulitis only. The topic of left-sided diverticulitis is large, and we had to limit our review to the most common form of diverticulitis. Second, we did not discuss medical treatments for diverticulitis currently being studied, such as mesalamine, rifaximin, and probiotics. These treatments may play a larger role in the management of diverticulitis in the future. Furthermore, the data supporting their use are heterogeneous and beyond the scope of this article. Third, we could not include all special populations and how to tailor diverticulitis management to these groups.

## Conclusions

This narrative review shares the most current standard of care for surgical management of diverticulitis and considers novel developments in the field. General surgeons should integrate this information into their current management to better serve their patients and treat diverticular disease.


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