The American Society of Colon and Rectal Surgeons Clinical Practice Guidelines for the Treatment of Left-Sided Colonic Diverticulitis

Jason Hall, M.D., M.P.H.[1] • Karin Hardiman, M.D., Ph.D.[2] • Sang Lee, M.D.[3]
Amy Lightner, M.D.[4] • Luca Stocchi, M.D.[5] • Ian M. Paquette, M.D.[6]
Scott R. Steele, M.D., M.B.A.[4] • Daniel L. Feingold, M.D.[7] • Prepared on behalf of the Clinical Practice Guidelines Committee of the American Society of Colon and Rectal Surgeons

1 Section of Colon and Rectal Surgery, Boston Medical Center, Boston University School of Medicine, Boston, Massachusetts
2 Division of Gastrointestinal Surgery, University of Alabama at Birmingham, Birmingham, Alabama
3 Division of Colon and Rectal Surgery, USC Keck School of Medicine, Los Angeles, California
4 Department of Colorectal Surgery, Cleveland Clinic Cleveland, Cleveland, Ohio
5 Division of Colorectal Surgery, Mayo Clinic Florida, Jacksonville, Florida
6 Division of Colon and Rectal Surgery, University of Cincinnati, Cincinnati, Ohio
7 Section of Colorectal Surgery, Rutgers University, New Brunswick, New Jersey

The American Society of Colon and Rectal Surgeons (ASCRS) is dedicated to ensuring high-quality patient care by advancing the science, prevention, and management of disorders and diseases of the colon, rectum, and anus. The Clinical Practice Guidelines Committee is composed of society members who are chosen because they have demonstrated expertise in the specialty of colon and rectal surgery. This committee was created to lead international efforts in defining quality care for conditions related to the colon, rectum, and anus and develop clinical practice guidelines based on the best available evidence. While not proscriptive, these guidelines provide information on which decisions can be made and do not dictate a specific form of treatment. These guidelines are intended for the use of all practitioners, health care workers, and patients who desire information about the management of the conditions addressed by the topics covered in these guidelines.These guidelines should not be deemed inclusive of all proper methods of care or exclusive of methods of care reasonably directed toward obtaining the same results. The ultimate judgment regarding the propriety of any specific procedure must be made by the physician in light of all the circumstances presented by the individual patient.

METHODOLOGY

These guidelines are constructed on the platform of the previously published Practice Parameters for the Treatment of Sigmoid Diverticulitis published by the American Society of Colon and Rectal Surgeons (ASCRS) in 2014.[1] A systematic search was conducted under the guidance of an information services librarian. This search strategy is outlined under the search appendices (see Supplemental Digital Content, http://links.lww.com/DCR/B209). The PubMed, EMBASE, Cochrane, and Web of Science databases were searched from January 1, 2013, until October 26, 2019. Relevant manuscripts identified by individual authors were also included. Key word combinations using the MeSH terms including "Diverticulitis," "Diverticulosis," "Diverticular," "Colonic," "Colon Diverticulosis," "Surgery," "Medical Therapy," "Antibiotics," "Probiotics," "Laparoscopic Lavage," "Mesalamine," "Rifaximin," and "Surgery" were performed. The search was limited to English language abstracts with human subjects. A directed search of ref-

CME Earn Continuing Education (CME) credit online at cme.lww.com.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text, and links to the digital files are provided in the HTML and PDF versions of this article on the journal's Web site (www.dcrjournal.com).

Funding/Support: None reported.

Financial Disclosures: None reported.

Correspondence: Daniel L. Feingold, M.D., Professor and Chair, Section of Colorectal Surgery, Rutgers University, New Brunswick, NJ.

Dis Colon Rectum 2020; 63: 728–747
DOI: 10.1097/DCR.0000000000001679

erences embedded in the candidate publications was also performed. Emphasis was placed on prospective trials, meta-analyses, systematic reviews, and practice guidelines. Peer-reviewed observational studies and retrospective studies were included when higher-quality evidence was insufficient. In brief, a total of 4885 unique journal titles were identified. Initial review of the search results led to the exclusion of 4223 titles based on irrelevance of the title or because they consisted of a case report, letter to the editor, or nonsystematic review. A review of the remaining 662 titles included assessment of the full-length articles. This led to exclusion of an additional 494 titles for which similar but higher-level evidence was available. The remaining 168 titles were considered for grading of the recommendations (Fig. 1). The final source material used was evaluated for the methodological quality, the evidence base was examined, and a treatment guideline was formulated by the subcommittee for this guideline. The final grade of recommendation and level of evidence for each statement were determined using the Grades of Recommendation, Assessment, Development, and Evaluation system (Table 1).[2] When agreement was incomplete regarding the evidence base or treatment guideline, consensus from the committee chair, vice chair, and 2 assigned reviewers determined the outcome. Members of the ASCRS Clinical Practice Guidelines Committee worked in joint production of these guidelines from inception to publication. Recommendations formulated by the subcommittee were reviewed by the entire Clinical Practice Guidelines Committee. The submission was peer-reviewed by *Diseases of the Colon & Rectum* and the final recommendations were approved by the ASCRS Executive Council. In general, each ASCRS Clinical Practice Guideline is updated every 5 years. No funding was received for preparing this guideline and the authors have declared no competing interests related to this material.

The terms uncomplicated and complicated diverticulitis, symptomatic uncomplicated diverticular disease (SUDD), and recurrent diverticulitis are used throughout this document. For purposes of this guideline, complicated diverticulitis is defined as diverticulitis associated with uncontained, free perforation with a systemic inflammatory response, fistula, abscess, stricture, or obstruction. Micro-perforation with small amounts of contained, extraluminal gas, in the absence of a systemic inflammatory response, is not considered complicated diverticulitis. Uncomplicated diverticulitis is defined as diverticulitis that is not associated with any of the aforementioned features.[3] Symptomatic uncomplicated diverticular disease is defined as diverticulosis with associated chronic abdominal pain in the absence of clinically overt colitis.[4] Meanwhile, the term recurrent diverticulitis has no universally accepted definition and the studies reviewed in this guideline used and defined recurrence differently.

STATEMENT OF THE PROBLEM

The prevalence of diverticular disease has risen steadily in industrialized nations over the past few decades.[5,6] A 2016 study using data from the National Inpatient Sample estimated that the prevalence of hospitalization for diverticulitis increased from 74.1 of 100,000 in 2000 to a peak of 96.0 of 100,000 in 2008.[7] These authors found that there were 2,151,023 hospitalizations for diverticulitis during this time period with an average of 195,548 admissions per year.[7] Another study compiled data from the National Ambulatory Medical Care Survey and the National Hospital Ambulatory Medical Care Survey and found that in 2010 there were more than 2.7 million discharges in the ambulatory setting associated with a diagnosis of diverticular disease, and that in 2012 there were more than 340,000 emergency department visits associated with a diagnosis of diverticulitis and 215,560 of these patients were admitted. Admission was associated with a median length of stay of 4 days and a median cost of treatment of US $6333.[8] The authors recently used updated data from the same 2 surveys and estimated that in 2014 there were 1.92 million patients diagnosed with diverticular disease in the ambulatory setting.[9]

Another contemporary analysis demonstrated that the rate of diverticulitis-related emergency department visits rose 26.8% from 89.8 to 113.9 visits per 100,000 population between 2006 and 2013 and that the aggregate national cost of these visits was $1.6 billion in 2013.[10]

As our understanding of diverticulitis has evolved, so have recommendations for the clinical management of these patients. Patients with diverticular disease are increasingly being treated as outpatients. Rates of admission to the hospital after emergency department evaluation for diverticulitis dropped from 58.0% in 2006 to 47.1% in 2013.[10] In addition, fewer patients are undergoing emergency bowel surgery; the rate of patients undergoing an intestinal operation per emergency department visit for diverticulitis decreased from 7278 of 100,000 to 4827 of 100,000 between 2006 and 2013.[10] Concomitantly, there has been an increase in the use of elective and laparoscopic surgery in the management of diverticulitis.[11]

This publication summarizes the changing treatment paradigm for patients with left-sided diverticulitis. Although diverticular disease can affect any segment of the large intestine, we will focus on left-sided disease. Bowel preparation, enhanced recovery pathways, and prevention of thromboembolic disease, while relevant to the management of patients with diverticulitis, are beyond the scope of these guidelines and are addressed in other ASCRS clinical practice guidelines.[12–14]

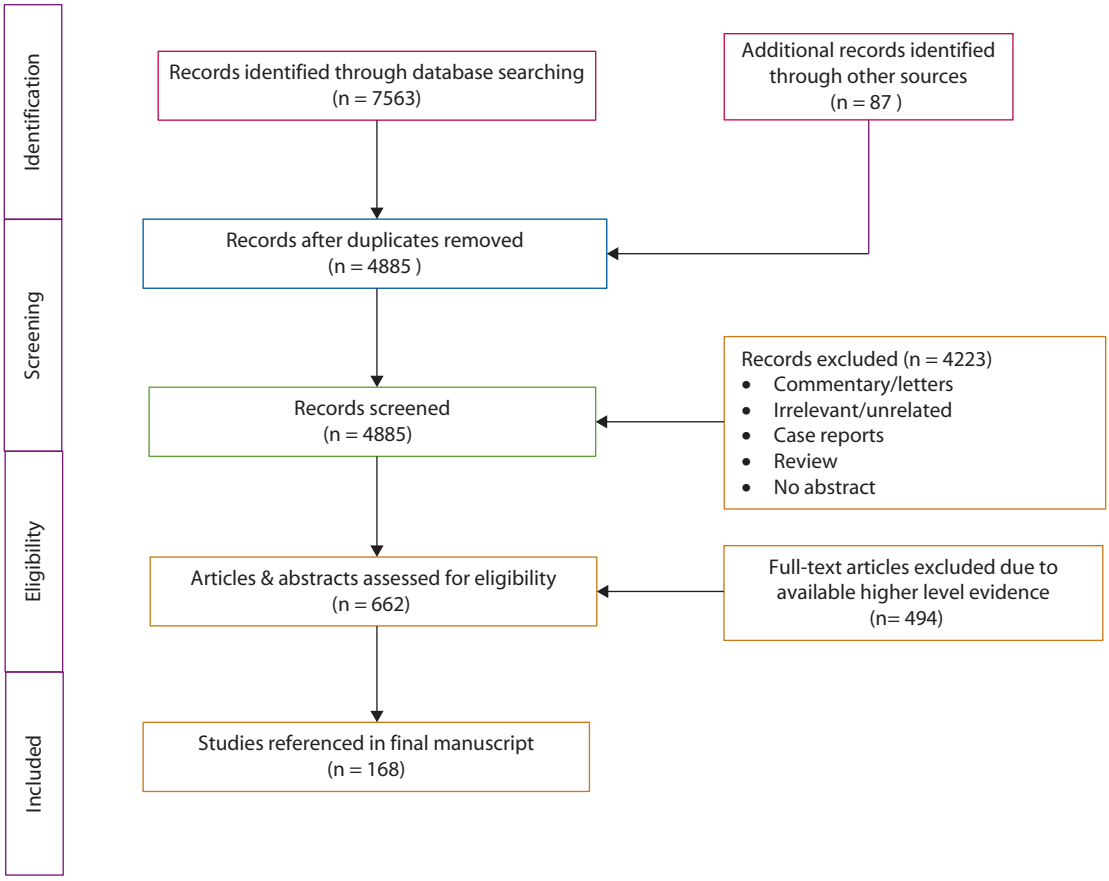

FIGURE 1. PRISMA literature search flow sheet.

INITIAL EVALUATION OF ACUTE DIVERTICULITIS

1. **The initial evaluation of a patient with suspected acute diverticulitis should include a problem-specific history and physical examination and appropriate laboratory evaluation. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.**

Classic findings related to sigmoid diverticulitis include left lower quadrant pain, fever, and leukocytosis. Fecaluria, pneumaturia, or pyuria are concerning for possible colovesical fistula, and stool per vagina is concerning for possible colovaginal fistula.

Physical examination, complete blood count, urinalysis, and abdominal radiographs can be helpful in refining the differential diagnosis. Other diagnoses to consider when patients present with suspected diverticulitis may include constipation, irritable bowel syndrome, appendicitis, IBD, neoplasia, kidney stones, urinary tract infection, bowel obstruction, and gynecologic disorders.

C-reactive protein (CRP), procalcitonin, and fecal calprotectin have been explored as potential predictors of diverticulitis severity.[15–17] C-reactive protein has been assessed as a marker of complicated diverticulitis in multiple case series in an attempt to identify a biomarker that can discriminate patients who have complicated disease. Many of the series are small and the suggested cutoff values vary.[18–22] However, in one retrospective study of 350 patients presenting with their first episode of diverticulitis, CRP >150 mg/L significantly discriminated acute uncomplicated from complicated diverticulitis and the combination of CRP >150 mg/L and free fluid on CT scan was associated with a significantly greater risk of mortality.[23] In a study of 115 patients, Jeger et al[15] demonstrated that procalcitonin was able to discriminate between patients with uncomplicated and complicated disease. Another study of 48 patients demonstrated that elevated fecal calprotectin was associated with diverticulitis recurrence.[17] Recently, a diagnostic prediction model differentiating uncomplicated diverticulitis from complicated diverticulitis (defined as Hinchey >Ia) was developed. Incorporating 3 parameters, abdominal guarding, CRP, and leukocytosis, this validated model had a negative predictive value for detecting complicated diverticulitis of 96%.[24] Additional studies are needed to elucidate the utility of laboratory testing in the setting of diverticulitis and, currently, the limited evidence does not support a particular management algorithm.

TABLE 1. The GRADE System: grading recommendations

Grade	*Description*	*Benefit versus risk and burdens*	*Methodological quality of supporting evidence*	*Implications*
1A	Strong recommendation, High-quality evidence	Benefits clearly outweigh risk and burdens or vice versa	RCTs without important limitations or overwhelming evidence from observational studies	Strong recommendation, can apply to most patients in most circumstances without reservation
1B	Strong recommendation, Moderate-quality evidence	Benefits clearly outweigh risk and burdens or vice versa	RCTs with important limitations (inconsistent results, methodological flaws, indirect, or imprecise) or exceptionally strong evidence from observational studies	Strong recommendation, can apply to most patients in most circumstances without reservation
1C	Strong recommendation, Low- or very-low-quality evidence	Benefits clearly outweigh risk and burdens or vice versa	Observational studies or case series	Strong recommendation but may change when higher-quality evidence becomes available
2A	Weak recommendation, High-quality evidence	Benefits closely balanced with risks and burdens	RCTs without important limitations or overwhelming evidence from observational studies	Weak recommendation, best action may differ depending on circumstances or patients' or societal values
2B	Weak recommendations, Moderate-quality evidence	Benefits closely balanced with risks and burdens	RCTs with important limitations (inconsistent results, methodological flaws, indirect or imprecise) or exceptionally strong evidence from observational studies	Weak recommendation, best action may differ depending on circumstances or patients' or societal values
2C	Weak recommendation, Low- or very-low-quality evidence	Uncertainty in the estimates of benefits, risks and burden; benefits, risk and burden may be closely balanced	Observational studies or case series	Very weak recommendations; other alternatives may be equally reasonable

GRADE = Grades of Recommendation, Assessment, Development, and Evaluation; RCT = randomized controlled trial.
Adapted from Guyatt G, Gutermen D, Baumann MH, et al. Grading strength of recommendations and quality of evidence in clinical guidelines: report from an American College of Chest Physicians Task Force. *Chest*. 2006;129:174–181.[2] Used with permission.

2. CT scan of the abdomen and pelvis is the most appropriate initial imaging modality in the assessment of suspected diverticulitis. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

Computed tomography imaging has become a standard tool to diagnose diverticulitis, assess disease severity, and help devise a treatment plan. Low-dose CT, even without oral or intravenous contrast media, is highly sensitive and specific (95% for each) for diagnosing acute abdominal complaints including diverticulitis as well as other etiologies that can mimic the disease.[25] Computed tomography findings associated with diverticulitis may include colonic wall thickening, fat stranding, abscess, fistula, and extraluminal gas and fluid and can stratify patients according to Hinchey classification.[26] The utility of CT imaging goes beyond the accurate diagnosis of diverticulitis; the grade of severity on CT correlates with the risk of failure of nonoperative management in the short term and with long-term complications such as recurrence, the persistence of symptoms, and the development of colonic stricture and fistula.[27–29]

3. Ultrasound and MRI can be useful alternatives in the initial evaluation of a patient with suspected acute diverticulitis when CT imaging is not available or is contraindicated. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Ultrasound and MRI may be useful in patients with a contrast allergy where CT can be challenging or in pregnant patients. Ultrasound can be particularly useful to rule out other causes of pelvic pain that can mimic diverticulitis when the diagnosis is unclear, especially in women.[30] However, ultrasound can miss complicated diverticulitis and thus should not typically be the only imaging modality utilized if this is suspected.[31] Although ultrasound evaluation is included as a diagnostic option in the practice guidelines of several societies, ultrasound is user dependent and its utility in obese patients may be limited.[32,33] Where available, MRI can also be useful in patients in whom CT is contraindicated and may be better than CT at differentiating neoplasia from diverticulitis.[34]

MEDICAL MANAGEMENT OF ACUTE DIVERTICULITIS

1. Selected patients with uncomplicated diverticulitis can be treated without antibiotics. Grade of Recommendation: Strong recommendation based on high-quality evidence, 1A.

Until recently, the routine use of antibiotics has been the primary treatment for patients presenting with acute diverticulitis. The generally accepted pathophysiologic mechanism of diverticulitis has been challenged because new evidence suggests that diverticulitis is primarily an inflammatory process that can result in micro-perforation rather than a complication of micro-perforation itself.[4] Two randomized controlled trials as well as systematic reviews have found no significant difference in outcomes of patients with uncomplicated diverticulitis treated with or without antibiotics.[35–38] The AVOD trial (Swedish acronym standing for "antibiotics in uncomplicated diverticulitis") randomly assigned 623 inpatients with CT-confirmed uncomplicated left-sided diverticulitis to receive intravenous fluids alone or intravenous fluids and antibiotics and found no differences between the treatment groups in terms of complications, recurrence, or time to recovery.[35] This study group recently published a long-term follow-up of this cohort. At a median follow-up of 11 years, the authors found no significant differences between the 2 groups in terms of recurrences (both 31.3%), complications, surgery for diverticulitis, or reported quality of life (EQ-5DTM).[39]

The most recent randomized controlled trial (DIABOLO) from The Dutch Diverticular Disease Collaborative Study Group compared the efficacy of treating patients presenting with their first episode of sigmoid diverticulitis with antibiotics versus observation.[36] Five hundred twenty-eight patients with CT-proven, uncomplicated diverticulitis were randomly assigned to either a 10-day course of amoxicillin-clavulanic acid (48 hours of intravenous treatment followed by oral administration) or observation in an outpatient setting, and the primary end point was time to recovery. The median time to recovery for the antibiotic treatment group was 12 days (interquartile range (IQR) 7–30) versus 14 days in the observation group (IQR 6–35; $p = 0.15$). There were no significant differences between the treatment groups in terms of the occurrence of mild or serious adverse events, but the antibiotic group had a higher rate of antibiotic-related adverse events (0.4% versus 8.3%; $p = 0.006$). After 24 months of follow-up, there were no significant differences between the 2 groups with regard to mortality, recurrent diverticulitis (uncomplicated or complicated), readmission, adverse events, or need for resection.[40]

A Cochrane review also found no significant differences in outcomes between patients with uncomplicated diverticulitis treated with or without antibiotics.[41] These studies suggest that a proportion of patients with uncomplicated diverticulitis can be treated without antibiotics. It is important to emphasize that nearly all of the patients included in these studies were relatively healthy and had early-stage diverticular disease (Hinchey I and Ia). Some investigators have also demonstrated that an antibiotic-free approach can be successful in the outpatient setting.[42]

A number of other systematic reviews and meta-analyses have also supported this approach.[37,43–46] A meta-analysis of 9 studies that included 2565 patients compared the efficacy of treatment with and without antibiotics. Two studies were randomized trials, 2 were prospective cohort studies, and 5 were retrospective analyses. The authors noted that there were no differences between the 2 groups in terms of rates of treatment failure, recurrence of diverticulitis, complications, readmission rates, need for surgery, or mortality. Treatment without antibiotics was more likely to fail in patients with associated comorbidities.[45] A retrospective study of 565 patients with Hinchey Ia disease found that those with a CRP >170 mg/dL had a higher risk of treatment failure when treated without antibiotics.[47] Another meta-analysis of 7 studies compared observational management and antibiotic treatment in 2321 patients and concluded that there were no significant differences between the groups in terms of emergency surgery (0.7% versus 1.4%; $p = 0.10$) and recurrence (11% versus 12%; $p = 0.30$). However, when the authors examined only randomized trials, elective surgery during follow-up occurred more frequently in the observational group than in the antibiotic group (2.5% versus 0.9%; $p = 0.04$).[37] Taken as a whole, these data suggest that antibiotic therapy may not be necessary in selected, otherwise healthy patients with early-stage diverticulitis.

2. Nonoperative treatment of diverticulitis may include antibiotics. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Before the 2 randomized trials questioning the benefit of antibiotics in uncomplicated diverticulitis, antibiotic therapy was and still is a standard component of the armamentarium used to treat all stages of this disease.[1] The use of antibiotics continues to be appropriate for higher-risk patients with significant comorbidities, signs of systemic infection, or immunosuppression. Both of the randomized trials supporting avoidance of antibiotics included only patients with early-stage disease (Hinchey I and Ia).[35,36] Therefore, the use of antibiotics continues to be appropriate in all other stages of the disease.

A randomized controlled trial of 106 patients with uncomplicated diverticulitis compared a short course of intravenous antibiotic treatment (4 days) to a more standard course (7 days) and found the shorter course was as effective as the longer course.[48] Another randomized trial of 132 patients examined outpatient versus inpatient administration of antibiotics for diverticulitis and demonstrated no significant clinical outcome differences between the groups, although there was a significantly lower cost associated with outpatient treatment.[49] A recent meta-analysis of 4 studies (355 patients) also suggested there was no difference in treatment failure (6% versus 7%; $p = 0.60$) or recurrence (8% versus 9%; $p = 0.80$) when the

initial episode of diverticulitis was treated with oral versus intravenous antibiotics.[37]

3. Image-guided percutaneous drainage is usually recommended for stable patients with abscesses >3 cm in size. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

Complicated diverticulitis with abscess formation occurs in 15% to 40% of patients who present with acute sigmoid diverticulitis. Overall, nonoperative treatment with either antibiotics alone or in combination with percutaneous drainage is successful in up to 80% of cases.[50–52] Treatment failure is typically defined as requiring surgery, developing worsening sepsis, or having a recurrent abscess within 30 days.[53]

Antibiotic treatment alone for abscesses smaller than 3 cm is typically successful and, in stable patients, treatment can usually be administered in the outpatient setting. When this approach fails, percutaneous drainage should be considered, particularly in patients with larger abscesses (>3 cm) where antibiotics alone have a much higher failure rate (up to 34%).[53,54] There is no correlation between abscess size and failure of percutaneous drainage.[53,55,56] Although recurrence after antibiotic treatment of diverticular abscesses ranges from 25% to 60% of patients, recurrence after percutaneous drainage is significantly lower (15%–25%).[50,57,58] Patients who do not have a safe access window for percutaneous drainage or who do not respond to medical treatment including percutaneous drainage should typically be considered for surgery. Laparoscopic abscess drainage rather than surgical resection can be considered in certain cases.[59]

4. Tobacco cessation, reduced meat intake, physical activity and weight loss are recommended interventions to potentially reduce the risk of diverticulitis. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

The progression of normal colonic architecture to diverticulosis and subsequent diverticulitis is not well understood but is multifactorial and involves diet, genetics, lifestyle, and, possibly, the microbiome.[60,61] In a prospective cohort study of 46,295 men from the Health Professionals Follow-Up Study, a "Western" dietary pattern (high in red meat, refined grains, and high-fat dairy) was associated with an increased risk of diverticulitis when compared to a "prudent approach" (high in fruits, vegetables, and whole grains). Men who consumed the highest quintile of a Western dietary pattern had a multivariate hazard ratio of 1.55 (95% CI, 1.20–1.99) for diverticulitis compared with men in the lowest quintile, and the authors attributed the association primarily to the intake of less fiber and more red meat.[62] Liu et al[63] demonstrated a similar pattern when they studied 907 incident cases of diverticulitis that were prospectively identified during 757,791 person-years of follow-up. They defined patients with a low-risk lifestyle as those who had an average red meat intake (<51 g per day), dietary fiber intake in the top 40% of the cohort (about 23 g per day), approximately 2 hours of exercise weekly, normal BMI between, and never smoked. They found an inverse linear relationship between the number of low-risk lifestyle factors and diverticulitis incidence (p for trend < 0.001). When all 5 low-risk factors were present, the relative risk of diverticular disease was 0.27 (95% CI, 0.15–0.48) leading these authors to recommend a low-risk lifestyle.

A variety of agents have been studied to try to prevent recurrent attacks of diverticulitis. Although a high-fiber diet is associated with a lower risk of having a first episode of acute diverticulitis, the utility of fiber supplements in secondary prevention of diverticulitis is unclear.[64–66]

Aune et al[67] performed a meta-analysis of 5 prospective studies that comprised 6076 cases of diverticular disease. The relative risk for having an initial episode of diverticular disease was 1.36 (95% CI, 1.15–1.61) for current smokers, 1.17 (95% CI, 1.05–1.31) for former smokers, and 1.29 (95% CI, 1.16–1.44) for the group including both current and former smokers ("ever smokers"). The relative risk for having a complication of diverticular disease (abscess or perforation) was 2.54 (95% CI, 1.49–4.33) for current smokers and 1.83 (95% CI, 1.25–2.67) for ever smokers, and the authors concluded that tobacco smoking is associated with an increased incidence of diverticular disease and its associated complications. The same authors also examined the role of obesity in a meta-analysis of 5 studies and found that the relative risk for a 5-unit increase in BMI was 1.31 (95% CI, 1.09–1.56) for having a first episode of diverticulitis and 1.20 (95% CI, 1.04–1.40) for having a diverticular disease-related complication.[68] Although data are still emerging, interventions such as weight reduction and smoking cessation may be recommended as strategies to reduce the incidence of diverticulitis, but the role of these strategies in secondary prevention is unclear.[67,68]

5. Mesalamine, rifaximin, and probiotics are not typically recommended to reduce the risk of diverticulitis recurrence but may be effective in reducing chronic symptoms. Grade of Recommendation: Weak recommendation based on moderate-quality evidence, 2B.

Interventions that have been studied with regard to the incidence of diverticulitis include mesalamine, rifaximin, and probiotics. Although some studies evaluating the efficacy of mesalamine in preventing SUDD demonstrated superiority over placebo, the majority of randomized controlled trials and meta-analyses do not demonstrate efficacy in preventing recurrence.[69–73] A recent meta-analysis of 6 randomized controlled trials demonstrated no difference between mesalamine and placebo regarding recurrent diverticulitis (OR, 1.20; 95% CI, 0.96–1.50; $p = 0.11$).

Although mesalamine does not seem to effectively reduce the incidence of recurrent diverticulitis, it may play a role in symptom resolution in patients with SUDD.[69,70]

A number of studies examining the efficacy of rifaximin in secondary prevention of acute diverticulitis reported promising results, albeit these utilized questionable methodology. In one study, patients were randomly assigned to a high-fiber diet with or without rifaximin, but, because of poor accrual, the study design was changed to a feasibility study and the study accrued only 165 patients. The study demonstrated a lower rate of recurrent diverticulitis in the fiber + rifaximin group in comparison with the fiber-alone group (10.4% versus 19.3%).[74] Another retrospective cohort of 142 patients with symptomatic diverticular disease treated with rifaximin demonstrated a reduction in disease symptoms like abdominal pain and tenderness, bloating, and disturbances in bowel habits.[75] An older meta-analysis of 4 randomized controlled trials including 1660 patients found that rifaximin plus fiber supplementation is effective in obtaining symptom relief at 1 year.[76]

Other studies have explored the possible effect of probiotics on the incidence of diverticulitis, although no standard probiotic regimen was used. A randomized controlled trial evaluated the effect of a combination of mesalamine and probiotics on recurrence of SUDD defined as the recurrence of abdominal pain scored as ≥5 (0 = best; 10 = worst) for at least 24 consecutive hours. A total of 210 patients were randomly assigned to mesalamine 1.6 g/day plus *Lactobacillus casei* placebo, active *L casei* plus mesalamine placebo, active *L casei* plus active mesalamine, and *L casei* placebo plus mesalamine placebo for 10 days per month for 12 months.[77] The authors found that *Lactobacillus* and mesalamine in combination reduced the chances of recurrence. These results must be interpreted with caution because the primary outcome was recurrence of symptoms and there was no evidence presented regarding patients' burden of disease as measured by imaging or inflammatory markers.

In general, studies evaluating the use of mesalamine, rifaximin, or probiotics are heterogeneous, and the routine use of these agents following an attack of diverticulitis is typically not recommended.[66]

EVALUATION AFTER RECOVERY FROM ACUTE DIVERTICULITIS

1. After resolution of an episode of acute complicated diverticulitis, the colon should typically be endoscopically evaluated to confirm the diagnosis if a colonoscopy has not been performed recently. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Patients with complicated diverticulitis are at risk of actually harboring an occult malignancy.[78,79] A systematic review and meta-analysis by Sharma and colleagues[80] demonstrated that the risk of malignancy was 11% in patients with complicated diverticulitis and was 0.7% in those with uncomplicated diverticulitis. Another recent systematic review found that the incidence of malignancy was 7.9% (95% CI, 3.9%–15.3%) in patients with complicated diverticulitis and was 1.3% (95% CI, 0.1%–2%) in those with uncomplicated diverticulitis.[81] The colon should typically be evaluated to exclude a malignancy in patients who have had an episode of complicated diverticulitis, and this examination is often performed about 6 weeks after the acute episode to decrease the likelihood of a procedure-related perforation.[1] It should be noted, however, that the data supporting this timing are scant. Lahat et al[82] randomly assigned 86 patients diagnosed with acute diverticulitis to either early colonoscopy during the index hospitalizaton (n = 45) or late colonoscopy 6 weeks later (n = 41). The study showed no differences in terms of safety or complications related to colonoscopy, and the authors concluded that early colonoscopy is feasible and safe under these circumstances. These data should be interpreted with caution because the authors did not report a sample size calculation or power analysis, and the results could be subject to a type II error.

Specific CT findings associated with an increased likelihood of finding occult malignancy on endoscopy include abscess, "shouldering" where the leading edges of the presumed inflammatory mass have a shelf-like appearance, obstruction, and mesenteric or retroperitoneal lymphadenopathy.[79,83] Multiple series and one systematic review have found that patients with uncomplicated diverticulitis diagnosed on CT are at risk of having colorectal cancer or advanced polyps similar to the general population and may not require further colonoscopies beyond those recommended for screening.[84–87] However, if imaging, symptoms (eg, narrowed stools, bleeding), or clinical recovery is atypical, patients with uncomplicated diverticulitis should typically undergo further assessment with colonoscopy.[88]

ELECTIVE SURGERY FOR ACUTE DIVERTICULITIS

1. After successful nonoperative treatment of a diverticular abscess, elective resection should typically be considered. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

In general, current literature suggests that patients who present with a diverticular abscess experience recurrences at a substantial rate. A number of large data sets, however, suggest that many of these recurrences can be managed nonoperatively and that there are many patients who do not experience a recurrence under these circumstances.[52] The recommendation to consider colectomy after successful medical treatment of an abscess therefore represents a change from the 2014

practice parameters that advised interval, elective colectomy after successful medical therapy of a mesocolic abscess ≥5 cm or a pelvic abscess.[1] While decreasing the risk of recurrence is an important factor, there are other considerations that influence the decision to undergo elective surgery, such as coexisting medical conditions, tolerance of surgical risk, etc.

A retrospective study from the California Office of Statewide Health Planning and Development database of 179,649 patients who were hospitalized with diverticulitis and managed medically found that patients who presented with a diverticular abscess were significantly more likely to have recurrent diverticulitis (HR, 2.02; 95% CI, 1.92–2.13) and to have a complicated recurrent attack (HR, 4.08; 95% CI, 3.79–4.40).[89] Another study examined 10,342 patients from the Statewide Planning and Research Cooperative System (New York State) who had a diverticular abscess. Of this cohort, 3270 patients (32%) underwent surgery within 30 days of diagnosis. Of the 7072 remaining patients, 1660 (24%) underwent elective colectomy within 6 months. The 5-year recurrence rate for the 5412 patients who did not undergo surgery within 6 months was substantial at 24.8% (median time to recurrence, 278 days (IQR, 93.5–707)).[52] A number of retrospective single-center cohort studies have suggested that recurrence rates range from 9.6% to 61% after having an abscess.[51,57,58,90,91]

Of particular interest are patients who had a diverticular abscess treated with a percutaneous drain. In a retrospective review of 185 patients with diverticular abscess treated initially without surgery, 112 patients (60.5%) had recurrent diverticulitis after an average of 5.3 months.[57] Notably, the modified Hinchey class at the time of recurrence compared with the index presentation increased in 51 of 112 patients (45.6%) and 29 of the 112 patients (26%) required urgent operation. Patients who experienced recurrent diverticulitis had significantly larger abscesses at their index presentation than patients who did not have recurrent diverticulitis (5.3 cm versus 3.2 cm; $p < 0.001$). Of the 65 patients who underwent percutaneous drainage, the recurrence rate was 74%.[57]

A retrospective, multi-institution study examined the outcomes of 447 patients with an initial episode of diverticular abscess, the majority of whom (74.3%) were treated without percutaneous drainage. These authors found no difference in treatment failure which was defined as the composite outcome of complications, readmissions, persistent diverticulitis, emergency surgery, death or need for percutaneous drainage in patients treated with antibiotics only at initial presentation. Patients with abscesses >3 cm in size were at higher risk of treatment failure (OR, 2.05; 95% CI, 1.09–3.86) within 30 days. Abscesses 5 cm or larger were associated with the need for surgery (OR, 2.96; 95% CI, 1.03–8.13) within 30 days.[51] In this study, age (HR, 1.02; 95% CI, 1.00–1.03) and history of diverticulitis (HR, 1.7; 95% CI, 1.17–2.48) were associated with recurrence after 30 days, whereas sigmoid resection within the first 30 days was inversely associated with recurrence (HR, 0.15; 95% CI, 0.05–0.48).

Another retrospective review of 73 patients with diverticular abscess managed with nonoperative intent and long-term expectant management documented a 30% recurrence rate over a median follow-up period of 62 months.[58] Nine of the 22 patients who experienced recurrence had repeat complicated attacks. A meta-analysis examining 22 studies including 739 patients regarding the long-term outcomes of patients who had a diverticular abscess successfully managed nonoperatively demonstrated a 28% diverticulitis recurrence rate, and the authors recommended that routine elective resection after successful medical treatment of a large abscess should be discussed with patients.[92]

Although recurrence rates are notable after medical management of a diverticular abscess, interval elective surgery may be omitted in certain situations with acceptable outcomes. A retrospective review of 32 patients with significant comorbidities who had percutaneous drainage of a diverticular abscess and did not undergo subsequent colectomy found that, over a 7-year follow-up, 5 (16%) patients had recurrences with uncomplicated diverticulitis and 4 (13%) patients had recurrent abscess requiring repeat percutaneous drainage.[93] All recurrences were managed nonoperatively. Patients who experienced recurrences were more likely to have had an abscess >5 cm ($p < 0.001$) at their index presentation. The authors concluded that expectant management after nonoperative management of a diverticular abscess is safe in selected patients.

In a retrospective review of 14,124 patients managed nonoperatively after their first episode of diverticulitis, patients with complicated disease had a higher readmission rate than patients with uncomplicated disease (12% versus 8.2%; $p < 0.001$) and an increased risk of having future emergency surgery (4.3% versus 1.4%; $p < 0.001$).[94] The authors concluded that the vast majority of patients managed medically will not require future readmission or emergency surgery and suggested that elective colectomy may not be routinely needed in this situation; however, they suggested that patients with higher-risk abscesses (larger size, pelvic location, or who required percutaneous drainage) are more suitable for elective colectomy.

2. Elective colectomy should typically be recommended for patients with diverticulitis complicated by fistula, obstruction, or stricture. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

A retrospective review of 672 patients followed after their first episode of diverticulitis treated medically found that patients with an index complicated presentation were significantly more likely to have a subsequent complicated recurrence compared with patients whose index presen-

tation was uncomplicated (HR, 14.6; 95% CI, 6.2–34.4).[29] In situations where diverticulitis is complicated by fistula formation, obstruction, or stricture, elective or semielective resection is generally recommended to provide symptomatic relief.[95] Neither phlegmon nor extraluminal gas alone seen on cross-sectional imaging is considered complicated disease, and these findings should not, in and of themselves, dictate a specific therapy. Rather, the clinician should consider these findings together with the clinical scenario when deciding on possible operative intervention.

3. Elective resection based on young age at presentation is not recommended. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Historically, diverticulitis among young patients has been associated with worse clinical outcomes.[96,97] In terms of a possible pathway for developing diverticulitis at a younger age, Coble et al[98] used whole exome sequencing and described genes associated with early-onset diverticulitis. These authors identified *LAMB4*, a gene localized to the colonic myenteric plexus, and proposed that decreased *LAMB4* levels may alter the function of the enteric nervous system leading to early-onset diverticulitis.

Young age has been used as an indication for elective surgery following recovery after an acute episode of even uncomplicated diverticulitis. Although the controversy persists regarding the risks for recurrence or complications for younger (age <50 years) versus older patients, more recent data suggest that age does not increase the risk for worse clinical outcomes. Although the literature describes higher recurrence rates with younger patients compared with older patients, younger patients do not necessarily have more complicated recurrences.[94,99,100] Although multiple national and statewide databases and systematic reviews demonstrate that younger patients are significantly more likely to require repeat hospitalization for diverticulitis, there are conflicting data regarding their lifetime risk of undergoing emergency surgery.[101–103] Li et al,[94] in a retrospective cohort study of 14,124 patients managed nonoperatively after a first attack of diverticulitis and followed over a median 3.9 years (IQR 1.7–6.4), demonstrated that younger patients had a higher rate of readmission (10.5% versus 8.4%; $p < 0.001$) but had a similar risk of requiring emergency surgery compared with older patients (1.8% versus 2.0%; $p = 0.52$).

A meta-analysis of 4982 patients with CT-confirmed diverticulitis demonstrated a higher rate of elective colectomy in younger patients (18.1% versus 8.5%; RR, 2.39; 95% CI, 1.82–3.15) which was felt to be due to a lower threshold for operating on younger patients who may have a higher risk of experiencing recurrent disease.[99] Another meta-analysis including 8 studies and 23,079 patients demonstrated a significantly increased risk of recurrent diverticulitis in younger patients (RR, 1.73; 95% CI, 1.40–2.13) and found that patients <50 years old more frequently underwent urgent surgery during subsequent episodes (RR, 1.46; 95% CI, 1.29–1.66).[104]

4. The decision to recommend elective sigmoid colectomy after recovery from uncomplicated acute diverticulitis should be individualized. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

Studies examining patients with uncomplicated diverticulitis treated nonoperatively report recurrence rates ranging from 13% to 33% and low rates of subsequent complicated disease or need for emergency operation.[29] After recovering from an initial episode of diverticulitis, the estimated risk of needing emergency surgery with stoma formation is 1 in 2000 patient-years of follow-up.[105] According to these data, 18 patients would need to undergo elective colectomy to prevent 1 emergency surgery for diverticulitis.[106] The practice of recommending elective colectomy to prevent a future recurrence requiring stoma formation is not supported by the literature and should be discouraged.

Retrospective review of a Washington State hospital discharge database analyzed 84,313 patients hospitalized for diverticulitis and demonstrated that, between 1987 and 2012, the elective colectomy rate more than doubled without a significant decrease in the rate of emergency surgery or percutaneous interventions.[107] This data set, together with the fact that 80% to 90% of emergency resections are performed during index attacks of diverticulitis, supports the practice of continued medical therapy rather than elective colectomy for patients with uncomplicated diverticulitis, because elective colectomy does not significantly reduce the rate of needing emergency surgery.[106,108,109]

Although patients who present with uncomplicated disease at their first attack are unlikely to have another attack (complicated or uncomplicated), patients who are admitted for a recurrence of uncomplicated diverticulitis are at increasing risk of having further attacks.[89,103] A review of 181,115 patients who recovered from their first episode of diverticulitis nonoperatively found that 8.7% of patients went on to have a second admission for diverticulitis.[110] Interestingly, of patients admitted twice, 23% required a third admission and, of the patients admitted 3 times, 36% ultimately required 4 or more hospitalizations. Because the risk of recurrence increases after each recurrence, at some point, patients may prefer resection over repeated medical therapy. Consideration of elective colectomy after repeated bouts of uncomplicated diverticulitis should assess the operative risks unique to the patient, the frequency and severity of prior flares (eg, missed work, need for hospitalization), persistent residual symptoms related or attributed to prior attacks, operative morbidity including anastomotic leak and stoma creation, the risk of persistent or recurrent abdominal symptoms after undergoing resection, as well as patient preferences.[107,111–113]

Although elective sigmoid resection addresses the risk of future recurrence as well as complications related to future diverticulitis, it may also, in certain patients, improve quality of life. In a prospective study of 45 patients who underwent elective laparoscopic colectomy after medical therapy for diverticulitis, 36 patients had significant improvement in their GI quality-of-life index (GIQLI).[114] Another retrospective study of 105 patients noted improvements in quality of life 12 months after surgery using a visual analog scale.[100] The DIRECT trial, a multicenter, randomized controlled trial of patients with recurrent diverticulitis or persistent abdominal complaints attributed to diverticular disease, compared 53 patients who underwent sigmoidectomy with 56 nonoperative patients in an intent-to-treat analysis.[115] The primary end point, GIQLI at 6 months, was significantly better in the resection group (mean difference, 14.2; $p < 0.001$). Of note, this trial was terminated because of difficulties with recruitment and had particularly high rates of stoma creation (21%) and anastomotic leak (15%). At 5-year follow-up, the surgery group continued to have higher quality of life in comparison with the nonoperative group (mean difference, 9.7; 95% CI, 1.7–17.7). The operative group also had improved SF-36 physical ($p = 0.03$), mental ($p = 0.01$), and pain ($p = 0.01$) scores.[116] A cost-effectiveness study using the data from these groups of patients 1 year after treatment found a 0.06 difference in quality-adjusted life-years between the groups favoring resection, and this difference increased to 0.43 at 5 years. The authors concluded that elective sigmoid resection in patients with recurring diverticulitis was cost-effective.[117]

The DIABOLO study which compared antibiotic and observational strategies for the management of diverticular disease recently published quality-of-life assessments (EuroQol 5D, Short Form-36, and GIQLI) measured at 3, 6, 12, and 24 months after random assignment. Patients who had the lowest 16% of scores measured at 12 and 24 months were considered to have persistent symptoms. Overall, 32.2% to 38.2% of patients had persistent symptoms after 1 or 2 years, depending on which questionnaire was assessed. Patients who reported increased pain scores on the GIQLI during the first 10 days of symptoms were more likely to have persistent complaints (OR, 2.77; 95% CI, 1.60–4.80). Patients who had prolonged resolution of symptoms (>28 days) on their index attack were also more likely to have persistent complaints (OR, 2.25; 95% CI, 1.31–3.88).[118] Taken together, these data suggest that some patients may have persistent symptoms following an episode of uncomplicated diverticulitis. In most patients, surgery is effective in relieving persistent symptoms following an attack of acute diverticulitis. The decision to proceed with surgery should be individualized through shared decision making, including considerations like lingering symptoms, lifestyle limitations, and concerns about recurrence of diverticulitis without undergoing resection, and recurrence or persistence of symptoms after resection.

5. The decision to offer sigmoid colectomy after recovery from uncomplicated acute diverticulitis in immunosuppressed patients should be individualized. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Immunocompromised patients are a unique group of patients that deserves consideration in terms of recommending an elective operation after medical therapy for diverticulitis. A retrospective review of the National Surgical Quality Improvement Program (NSQIP) database compared 736 immunosuppressed patients with 21,980 immunocompetent patients who underwent elective sigmoidectomy for diverticulitis.[119] Multivariate regression analysis found that the groups had comparable mortality, but the rates of major morbidity (OR, 1.46; 95% CI, 1.17–1.83) and wound dehiscence (OR, 2.69; 95% CI, 1.63–4.42) were significantly higher in the immunosuppressed group. The decision to proceed with colectomy in the elective setting for immunosuppressed patients should consider these increased risks.

A retrospective review of a single-institution experience over a 14-year interval compared 107 immunosuppressed patients with 550 immunocompetent patients who had successful medical management of their first episode of diverticulitis with a mean follow-up of 81.6 months.[120] The rate of recurrent diverticulitis was similar in both groups (21.5% of immunosuppressed patients versus 20.5% of immunocompetent patients; $p = 0.82$). Although immunosuppressed patients who had a severe first episode (defined as abscess or perforation) were significantly more likely to have a recurrence or a complicated recurrence, the rate of requiring emergency surgery was comparable between the 2 groups. The authors concluded that, due to low recurrence rates and the low risk of needing emergency surgery, immunosuppressed patients successfully treated nonoperatively for uncomplicated diverticulitis do not typically require interval elective sigmoidectomy.

A single-institution retrospective review compared 12 patients who underwent renal transplant (median follow-up, 33 months) with 93 immunocompetent patients (median follow-up, 41 months) after successful medical therapy for diverticulitis.[121] Although there was no difference in recurrence rates between the groups, the recurrence rates across the board were high (42% in patients receiving transplants versus 57% in immunocompetent patients; $p = 0.37$). These authors concluded that nonoperative management of patients undergoing renal transplant with uncomplicated disease is safe and challenged the 2014 ASCRS clinical practice guideline that recommended maintaining a low threshold for colectomy in these patients.[1]

Other authors, citing small series of patients undergoing transplant and patients on steroids, recommend colectomy for immunosuppressed patients after one episode of diverticulitis and usually during the index admission.[122] A retrospective review that included 14 "high-risk" patients with immunosuppression, chronic renal failure, and/or collagen vascular disease and 74 patients without these conditions who were followed after successful nonoperative treatment of diverticulitis found that the "high-risk" patients had a 5-fold higher risk of future diverticulitis with perforation (36% versus 7%; $p = 0.002$).[95]

The authors concluded that because of the high mortality and morbidity associated with elective resection in patients with end-stage renal disease, colectomy should be reserved for patients "in whom surgery cannot be avoided." The literature supporting a low threshold for elective resection after a single episode of uncomplicated diverticulitis in immunosuppressed patients is not compelling. Whether or not the specific cause of immunosuppression (eg, organ transplant, end-stage renal disease, connective tissue disease) should influence treatment recommendations is unknown, because much of the literature pools data across the spectrum of immunosuppression.

EMERGENCY SURGERY FOR ACUTE DIVERTICULITIS

1. Urgent sigmoid colectomy is typically advised for patients with diffuse peritonitis or for those in whom nonoperative management of acute diverticulitis fails. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.

Although the majority of patients hospitalized for diverticulitis respond to nonoperative treatment, 15% to 32% may require an emergency operation.[51,123] Emergent indications for operation typically include patients with multiquadrant peritonitis or overwhelming systemic inflammatory response due to purulent or feculent peritonitis who are acutely ill and/or appear toxic. These patients generally require expedited fluid resuscitation, antibiotic administration, and operation. In a retrospective NSQIP study evaluating complications after emergency colectomy for diverticulitis in 2214 patients, the overall 30-day operative mortality was 5.1%.[123] Predictors of mortality included age >80 years, ASA class 4 or 5, serum creatinine >1.2 mg/dL, and an albumin <2.5 g/dL. Patients with 2, 3, or 4 of these predictors had a 30-day mortality rate of 10%, 22.9%, and 53.4%.

There is a small proportion of highly selected, stable patients with perforated diverticulitis, even with pneumoperitoneum but without diffuse peritoneal findings, who may be successfully managed nonoperatively in the acute setting.[124] In these selected situations, attempts can be made to convert an urgent or emergent operation to an elective operation to try to reduce postoperative morbidity and mortality.

Other patients may undergo semielective or otherwise nonelective operation after a more indolent course. For instance, patients who do not significantly improve from a clinical standpoint with medical therapy or continue with significant abdominal pain or the inability to tolerate enteral nutrition are typically recommended to undergo colectomy, although they may not have evidence of a significant systemic inflammatory response. Although repeat abdominal imaging to evaluate potential abscess formation or to otherwise guide management of antibiotic coverage and parenteral nutrition may be useful, clinical judgment ultimately determines the need for definitive surgical treatment in this setting.

2. Following resection, the decision to restore bowel continuity should incorporate patient factors, intraoperative factors, and surgeon preference. Grade of Recommendation: Strong recommendation based on moderate-quality evidence, 1B.

Once the diseased colon is resected, the surgeon may complete the operation by performing a primary colorectal anastomosis with or without a diverting colostomy or ileostomy or by constructing an end-colostomy with a Hartmann stump. Although a Hartmann procedure was once considered standard for emergency surgery in diverticulitis, there is now an abundance of randomized and administrative data demonstrating significantly improved morbidity and mortality rates following resection and primary anastomosis with or without stoma formation.[125–128] On the basis of the available newer evidence, this clinical practice guideline recommendation has been changed from a strong recommendation based on low-quality evidence (1C) in the 2014 guideline to a strong recommendation based on moderate-quality evidence (1B).[1]

Binda et al[125] randomly assigned patients with diverticulitis and peritonitis to sigmoid resection and primary anastomosis or Hartmann procedure, but this study was closed due to difficulties in recruiting patients. Over 9 years, 34 patients were randomly assigned to the primary anastomosis arm and 56 to the Hartmann arm. These authors reported no statistically significant differences in mortality between primary anastomosis and Hartmann patients (2.9% versus 10.7%; $p = 0.24$) or morbidity (35.3% versus 46.4%; $p = 0.38$), and stoma reversal rates were comparable (64.7% versus 60%; $p = 0.65$). However, patients who had a Hartmann procedure had significantly higher rates of morbidity from stoma reversal (23.5% versus 4.5%; $p = 0.05$).

The ColonPerfRCT (n = 62) and DIVERTI (n = 102) trials reported similar findings.[126,127] In both trials, patients with Hinchey stage III or IV diverticulitis under-

going emergency surgery were randomly assigned to a primary anastomosis with diverting loop ileostomy versus Hartmann procedure. Both studies found no differences in overall morbidity and mortality, but complications with stoma reversal were significantly reduced in the proximal diversion group in the ColonPerfRCT trial and long-term stoma-free rates were significantly higher in the proximal diversion groups in both trials (90% versus 57%; $p = 0.005$ and 96% versus 65%; $p = 0.0001$). In fact, accrual to the ColonPerfRCT study was terminated early because an interim safety analysis found that Hartmann reversal had significantly more serious complications (20% versus 0%) compared with ileostomy reversal. The DIVERTI trial was unable to accrue its targeted 246 patients by the end of the study period.

In 2019, the DIVA arm of the LADIES trial published its findings.[128] This study randomly assigned 133 patients with Hinchey III or IV disease to Hartmann procedure versus sigmoid resection with primary anastomosis, with or without defunctioning ileostomy. The decision to perform fecal diversion after primary anastomosis was left to the discretion of the surgeon. Twelve-month stoma-free survival was significantly higher in patients undergoing primary anastomosis compared with Hartmann procedure (94.6% versus 71.7%; HR, 2.79; 95% CI, 1.86–4.18). There were no significant differences between the Hartmann and primary anastomosis groups in terms of morbidity (44% versus 39%; $p = 0.60$) or mortality (3% versus 6%; $p = 0.44$) after the index procedure. These authors concluded that a primary anastomosis is preferable to a Hartmann procedure for perforated Hinchey III or IV disease.

Gachabayov et al[129] performed at meta-analysis of 17 studies, including 3 of the 4 randomized studies mentioned above, and concluded that primary anastomosis was associated with lower rates of organ space infection and stoma nonreversal rates.[125–127] Another recent meta-analysis included 3292 patients from observational studies and demonstrated that primary anastomosis had a lower mortality rate in comparison with the Hartmann procedure (8.2% versus 10.8%; OR, 0.60; 95% CI, 0.38–0.95; $p = 0.03$).[130] Meanwhile, meta-analysis including 3 randomized controlled trials did not demonstrate significant differences in mortality (OR, 0.44; 95% CI, 0.14–1.34) or wound infection (OR, 0.75; 95% CI, 0.20–2.78) when comparing primary anastomosis and Hartmann procedure.[125–127,130]

A recent meta-analysis including 3 of the 4 randomized trials examining primary anastomosis for acute diverticulitis and 3 randomized trials that also examined laparoscopic lavage demonstrated that outcomes for primary anastomosis versus Hartmann procedure were equivalent across a number of categories including overall morbidity and mortality.[125,126,131–134] Sigmoid resection with primary anastomosis had similar rates of major complications (RR, 0.88; 95% CI, 0.49–1.55) and postoperative mortality (RR, 0.58; 95% CI, 0.20–1.70) in comparison with the Hartmann procedure. Patients who underwent primary resection and anastomosis were more likely to be stoma-free at 12 months compared with patients who underwent the Hartmann procedure (RR, 1.40; 95% CI, 1.18–1.67) and had fewer major complications related to stoma reversal (RR, 0.26; 95% CI, 0.07–0.89).[131] These authors recently updated their meta-analysis to include the results of the LADIES trial and found that patients undergoing primary anastomosis were more likely to be stoma-free 12 months after initial surgery (RR, 1.34; 95% CI, 1.15–1.54).[135] There were no significant differences in major postoperative complications (RR, 0.88; 95% CI, 0.59–1.32) or postoperative mortality (RR, 0.84; 95% CI, 0.34–2.08) but there was a lower risk of complications following stoma reversal when comparing patients who underwent primary anastomosis in comparison with patients who underwent Hartmann procedures (RR, 0.23; 95% CI, 0.07–0.70).[135] These authors concluded that primary anastomosis is the procedure of choice for Hinchey III and IV diverticulitis in stable patients and that "there is no additional need for further randomized trials or meta-analyses to explore this question. Instead, efforts should be focused on translation of this evidence into practice."

A more recent analysis of the NSQIP database evaluating 2729 patients who required emergency operation for diverticulitis found that patients who underwent Hartmann procedures (n = 2521) had more comorbidities (eg, chronic obstructive pulmonary disease: 9.8% versus 4.8%; $p = 0.01$) and were more frequently in septic shock (11.1% versus 5.3%; $p = 0.01$) compared with patients who underwent primary anastomosis with diverting loop ileostomy (n = 208) and had a higher mortality (7.6% versus 2.9%; $p = 0.01$). After adjusting for multiple confounders on multivariable analysis, patients who underwent primary anastomosis with ileostomy did not have a higher risk of postoperative morbidity (OR, 0.96; 95% CI, 0.63–1.45). These authors concluded that primary anastomosis with ileostomy appears to be a safe alternative to Hartmann procedure in the emergency setting.[136]

As creating a primary anastomosis at the time of emergency surgery for diverticulitis is increasingly popularized, the role of proximal diversion under these circumstances has been studied but remains unclear. Another NSQIP study regarding patients undergoing emergency surgery for diverticulitis compared patients who underwent a Hartmann procedure (n = 991), primary anastomosis (n = 285), or primary anastomosis with proximal diversion (n = 38) and found no differences in morbidity and mortality when comparing the 3 groups of patients; however, there was a trend toward increased mortality and postoperative sepsis when diversion was not utilized in the setting of a primary anastomosis.[137] The small number of patients who underwent primary anastomosis with diverting ileostomy in this study weakens the conclusions of the article.

Other variables that have been studied regarding whether or not to create an anastomosis in the setting of emergency surgery for diverticulitis include the training of the surgeon involved and the applicability of this approach in immunosuppressed patients. A recent study that used a New York State all-payer sample database compared 10,600 patients who underwent urgent or emergent Hartmann procedure with 180 patients who underwent primary anastomosis with proximal diversion over a 15-year interval. This study demonstrated a 2-fold greater risk of postoperative mortality when noncolorectal surgeons performed a primary anastomosis in comparison with colorectal surgeons (15% versus 7.4%; $p < 0.001$). In this study, a colorectal surgeon was defined as a surgeon who was board certified in Colon and Rectal Surgery.[138] With regard to immunosuppressed patients, although there is a well-established increased morbidity and mortality following emergency surgery, primary anastomosis appears to be safe in selected patients.[139]

Recent data suggest that, despite recommendations regarding the outcomes of primary anastomosis, adoption rates of this approach remain low (3.9%).[140] The decision to restore intestinal continuity and whether to perform proximal diversion in the setting of a primary anastomosis should be individualized as the clinician considers the risks associated with anastomotic failure. Parameters generally favoring colostomy and Hartmann procedure include patient and intraoperative factors such as hemodynamic instability, acidosis, acute or chronic organ failure, and immunosuppression. There may be a role for Hartmann procedure in certain patients, typically older, with poor bowel function and sphincter tone, in whom GI continuity may not be considered as high a priority secondary to quality-of-life considerations. Quality-of-life data obtained after undergoing emergency surgery for diverticulitis documented worse quality of life following the Hartmann procedure compared with patients who underwent resection with primary anastomosis; which was mainly due to the presence of an end colostomy.[141] Ultimately, surgeon preference and experience will determine the most appropriate course.

LAPAROSCOPIC LAVAGE

1. Laparoscopic lavage is not recommended in patients with feculent peritonitis; rather, colectomy should typically be performed in this situation. Grade of Recommendation: Strong recommendation based on high-quality evidence, 1A.

The role of laparoscopic lavage has been evaluated by multiple retrospective series and 3 randomized controlled trials (LOLA, SCANDIV, and DILALA) that compared lavage with sigmoid resection. The first 2 trials reported 1-year data and the DILALA trial reported 2-year follow-up data.[132–134,142–144] Inclusion criteria, operative techniques, and end points were substantially heterogeneous between the studies, which limits the ability to compare their results. In all cases, Hinchey IV disease was excluded and the majority of patients treated with laparoscopic lavage had purulent peritonitis (Hinchey III). Because laparoscopic lavage has not been critically studied in patients with Hinchey IV diverticulitis, these patients should typically be treated with resection.

2. In patients with purulent peritonitis, colectomy is preferred over laparoscopic lavage. Laparoscopic lavage is associated with higher rates of secondary intervention in comparison with colectomy. Grade of Recommendation: Strong recommendation based on high-quality evidence, 1A.

The actual technique of laparoscopic lavage used in the 3 randomized controlled trials studying this approach was not uniform and the trials were designed differently and examined different end points.[132–134] The volume of saline irrigation, number of drains used, and management of intraoperative adhesions around the area of presumed diverticular perforation varied across the studies. With respect to examined outcomes, the LOLA trial used a composite end point of morbidity and mortality, the SCANDIV trial used the rate of severe postoperative complications within 90 days (Clavien-Dindo >3a), and the DILALA trial compared reoperation rates within 12 months postoperatively.[132–134,143]

In the LOLA trial, an interim analysis demonstrated a significantly increased rate of short-term serious adverse events in the lavage group in comparison with the sigmoidectomy group (39% versus 19%; $p = 0.04$).[145] Specifically, the laparoscopic lavage group had higher rates of surgical reintervention (20% versus 7%; $p = 0.12$), although this was not statistically significant, and higher rates of abscesses requiring drainage (20% versus 0%; $p = 0.002$). These data led to early termination of the trial by the data and safety monitoring board. The primary composite end point (morbidity and mortality) assessed at 12 months was comparable between the laparoscopic lavage and sigmoid resection groups (67% versus 60%; $p = 0.58$). Following laparoscopic lavage, 52% of patients did not require any acute or elective surgical intervention, and 74% of patients never required a stoma.[145]

In the SCANDIV trial, the rate of severe complications among patients with purulent peritonitis was comparable between the groups at 90 days and also 1 year after surgery.[134,142] The rates of deep surgical site infection (32% versus 13%; $p = 0.006$) and unplanned reoperation (27% versus 10%; $p = 0.01$) were higher in the laparoscopic lavage group. The lavage group, however, had lower rates of superficial wound infection (1% versus 17%; $p = 0.001$) and stoma formation (14% versus 42%; $p < 0.001$). Colon

adenocarcinoma was ultimately found in 4 patients following laparoscopic lavage and in 2 patients who underwent sigmoid resection.

In the DILALA trial, when reoperations within 30 days were compared, there was no difference between the laparoscopic lavage and Hartmann groups (13.2% versus 17.1%; $p = 0.67$). When all reoperations after the index treatment were assessed, the laparoscopic lavage group resulted in a 45% reduced risk of undergoing one or more reoperations within 24 months of surgery.[133,144]

A number of meta-analyses and systematic reviews have attempted to clarify the contradictory results of studies regarding laparoscopic lavage. A review of 589 patients from the 3 randomized controlled trials and 4 comparative studies comparing resection to lavage found that laparoscopic lavage was more frequently used in younger patients with lower ASA grade and higher BMI.[146] Mortality, 30-day reoperation, and unplanned readmission rates were similar between the groups. The advantages of laparoscopic lavage included shorter operative times, reduced risk of wound infection, cardiac complications, and stoma formation, shorter length of hospital stay, and, based on the results of one trial, reduced costs.[147] However, laparoscopic lavage was associated with significantly increased risks of intra-abdominal abscess, peritonitis, and future emergency reoperation. Over 90% of patients undergoing resection required a stoma (colostomy or diverting ileostomy) in comparison to 14% after laparoscopic lavage. The rate of stoma takedown in the resection group was 74% at 1 year, whereas patients who had a stoma following laparoscopic lavage had a lower rate of stoma reversal (48%) at 1 year. It is important to note that, in this analysis, 36% of patients who underwent laparoscopic lavage had a sigmoid colectomy within 1 year.[146]

Some patients with purulent peritonitis can be effectively treated with laparoscopic lavage and avoid the longer recovery, morbidity, and risk of a stoma associated with a sigmoid resection. However, laparoscopic lavage is also associated with an increased risk of unresolved or recurrent diverticulitis, abscess formation, and having an incompletely sealed perforation, fecal peritonitis, fecal fistula, and sigmoid adenocarcinoma.[131,148] Studies are needed to better identify selection criteria for patients who might benefit from laparoscopic lavage and to standardize the operative technique. Surgeons utilizing laparoscopic lavage should be aware of the clinical outcomes and risk of unresolved septic foci associated with this approach, and should be prepared to offer secondary interventions, as needed.

TECHNICAL CONSIDERATIONS

1. **The extent of elective resection should include the entire sigmoid colon with margins of healthy colon and rectum. Grade of Recommendation: Strong recommendation based on low-quality evidence, 1C.**

The principles of surgical management are the same when operating for complicated and uncomplicated diverticular disease. Once the diseased segment of colon is removed, intestinal continuity is typically restored depending on the specific clinical circumstances. Although the proximal resection margin should be in soft, pliable, colon without gross evidence of inflammation, it is not necessary to resect all proximal diverticula. The distal resection margin should be in a healthy rectum because anastomosis to the distal sigmoid is associated with a higher risk of recurrent diverticulitis.[149,150] It may be necessary to mobilize the splenic flexure to perform a tension-free anastomosis; alternatively, rectal mobilization can also afford additional length and may be required to address postinflammatory rectal strictures that can interfere with passing the circular stapler and with creating an anastomosis. Some studies suggest that a mid-mesenteric dissection with preservation of the inferior mesenteric artery may decrease the incidence of anastomotic leak; however, one meta-analysis failed to demonstrate a significant benefit with this approach.[151–153]

2. **When expertise is available, a minimally invasive approach to colectomy for diverticulitis is preferred. Grade of Recommendation: Strong recommendation based on high-quality evidence, 1A.**

The advent of minimally invasive surgery has ushered in a new era in the surgical management of diverticular disease, and in the past decade increasing numbers of resections for diverticular disease have been performed laparoscopically.[11] Whereas the relevant literature is retrospective in nature and subject to selection bias, there is substantial evidence supporting the use of laparoscopy when the operating surgeon feels this is a safe approach after accounting for individual factors such as hemodynamic stability, bowel dilation, previous abdominal surgery, and the presence of comorbidities.[154–156] Similar to the well-described advantages of a laparoscopic approach for elective sigmoid resection, there is now literature, although retrospective, supporting the use of laparoscopy for emergent sigmoid resection and subsequent ostomy reversal.[157–160] A retrospective cohort analysis of 42 patients undergoing surgery after failed medical management of complicated diverticulitis demonstrated a 4-fold decrease in postoperative morbidity and significantly shorter hospital stay in patients who underwent a laparoscopic approach in comparison with those who had an open approach.[158] A propensity-matched analysis using NSQIP data also demonstrated fewer overall complications and equivalent mortality rates in patients who underwent an emergency laparoscopic Hartmann procedure compared with an open approach.[161]

Robotic surgery has also been applied to the minimally invasive management of diverticular disease and initial reports suggest that clinical outcomes are similar to laparoscopy.[162,163] A NSQIP study comparing 472 ro-

botic colorectal operations with 8392 laparoscopic cases found that there was lower risk of conversion with the robotic approach (9.5% versus 13.7%; $p = 0.008$).[164] Another study including 128,288 colorectal procedures from the National Inpatient Sample examined the use of robotic surgery and also found that conversion was significantly lower with robotic surgery; however, hospital charges were significantly higher.[165] A retrospective study from the Premier Healthcare Database of 2418 propensity-matched patients who underwent elective sigmoid colectomy for diverticular disease found that patients who underwent robotic surgery had fewer conversions, shorter length of hospital stay, fewer postoperative complications, and less ileus in comparison with patients who underwent laparoscopic sigmoid colectomy (all p values <0.05). Although this study used propensity score matching to account for differences in the groups, selection bias could not be completely mitigated.[166]

Another single-center, retrospective diverticulitis study compared 66 robotic sigmoid resections with 222 propensity-matched laparoscopic cases. There were no significant differences in time to first bowel movement (1 versus 2 days), length of stay (3.5 versus 3.6 days), or opioid use within 72 hours of surgery (110.8 morphine milligram equivalents versus 97.4 morphine milligram equivalents) between the groups. Robotic hospital charges were significantly increased when compared to laparoscopy ($41,159 versus $25,761; $p < 0.001$).[167]

In a propensity-matched, retrospective study of 114 patients undergoing sigmoidectomy for neoplasia or diverticulitis, Al Natour et al[168] found that robotic resection with intracorporeal anastomosis was associated with decreased rates of conversion (5.2% versus 19.3%; $p = 0.02$) and incisional hernia (0% versus 11%; $p = 0.02$) in comparison with robotic sigmoidectomy with extracorporeal anastomosis. There were no significant differences in time to return of bowel function, length of hospital stay, rates of postoperative complications, or hospital readmission; however, the intracorporeal approach was associated with longer operative times (193.33 versus 159.89 minutes; $p < 0.001$).

REFERENCES

1. Feingold D, Steele SR, Lee S, et al. Practice parameters for the treatment of sigmoid diverticulitis. *Dis Colon Rectum.* 2014;57:284–294.
2. Guyatt G, Gutterman D, Baumann MH, et al. Grading strength of recommendations and quality of evidence in clinical guidelines: report from an american college of chest physicians task force. *Chest.* 2006;129:174–181.
3. Hall J, Hammerich K, Roberts P. New paradigms in the management of diverticular disease. *Curr Probl Surg.* 2010;47:680–735.
4. Rezapour M, Ali S, Stollman N. Diverticular disease: an update on pathogenesis and management. *Gut Liver.* 2018;12:125–132.
5. Heise CP. Epidemiology and pathogenesis of diverticular disease. *J Gastrointest Surg.* 2008;12:1309–1311.
6. Ricciardi R, Baxter NN, Read TE, Marcello PW, Hall J, Roberts PL. Is the decline in the surgical treatment for diverticulitis associated with an increase in complicated diverticulitis? *Dis Colon Rectum.* 2009;52:1558–1563.
7. Wheat CL, Strate LL. Trends in hospitalization for diverticulitis and diverticular bleeding in the United States from 2000 to 2010. *Clin Gastroenterol Hepatol.* 2016;14:96–103.e1.
8. Peery AF, Crockett SD, Barritt AS, et al. Burden of gastrointestinal, liver, and pancreatic diseases in the United States. *Gastroenterology.* 2015;149:1731–1741.e3.
9. Peery AF, Crockett SD, Murphy CC, et al. Burden and cost of gastrointestinal, liver, and pancreatic diseases in the United States: Update 2018. *Gastroenterology.* 2019;156:254–272.e11.
10. Bollom A, Austrie J, Hirsch W, et al. Emergency department burden of diverticulitis in the USA, 2006–2013. *Dig Dis Sci.* 2017;62:2694–2703.
11. Masoomi H, Buchberg B, Nguyen B, Tung V, Stamos MJ, Mills S. Outcomes of laparoscopic versus open colectomy in elective surgery for diverticulitis. *World J Surg.* 2011;35:2143–2148.
12. Migaly J, Bafford AC, Francone TD, et al; Clinical Practice Guidelines Committee of the American Society of Colon and Rectal Surgeons. The American Society of Colon and Rectal Surgeons clinical practice guidelines for the use of bowel preparation in elective colon and rectal surgery. *Dis Colon Rectum.* 2019;62:3–8.
13. Carmichael JC, Keller DS, Baldini G, et al. Clinical practice guideline for enhanced recovery after colon and rectal surgery from the American Society of Colon and Rectal Surgeons (ASCRS) and Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). *Surg Endosc.* 2017;31:3412–3436.
14. Fleming F, Gaertner W, Ternent CA, et al. The American Society of Colon and Rectal Surgeons clinical practice guideline for the prevention of venous thromboembolic disease in colorectal surgery. *Dis Colon Rectum.* 2018;61:14–20.
15. Jeger V, Pop R, Forudastan F, Barras JP, Zuber M, Piso RJ. Is there a role for procalcitonin in differentiating uncomplicated and complicated diverticulitis in order to reduce antibiotic therapy? A prospective diagnostic cohort study. *Swiss Med Wkly.* 2017;147:w14555.
16. Kiewiet JJ, Andeweg CS, Laurell H, et al. External validation of two tools for the clinical diagnosis of acute diverticulitis without imaging. *Dig Liver Dis.* 2014;46:119–124.
17. Tursi A, Elisei W, Picchio M, Brandimarte G. Increased faecal calprotectin predicts recurrence of colonic diverticulitis. *Int J Colorectal Dis.* 2014;29:931–935.
18. Hogan J, Sehgal R, Murphy D, O'Leary P, Coffey JC. Do inflammatory indices play a role in distinguishing between uncomplicated and complicated diverticulitis? *Dig Surg.* 2017;34:7–11.
19. Kechagias A, Rautio T, Kechagias G, Mäkelä J. The role of C-reactive protein in the prediction of the clinical severity of acute diverticulitis. *Am Surg.* 2014;80:391–395.
20. Kechagias A, Rautio T, Mäkelä J. The early c-reactive protein trend does not have a role in monitoring acute diverticulitis progression. *Chirurgia (Bucur).* 2016;111:43–47.
21. Mäkelä JT, Klintrup K, Rautio T. The role of low CRP values in the prediction of the development of acute diverticulitis. *Int J Colorectal Dis.* 2016;31:23–27.

22. Nizri E, Spring S, Ben-Yehuda A, Khatib M, Klausner J, Greenberg R. C-reactive protein as a marker of complicated diverticulitis in patients on anti-inflammatory medications. *Tech Coloproctol.* 2014;18:145–149.
23. Mäkelä JT, Klintrup K, Takala H, Rautio T. The role of C-reactive protein in prediction of the severity of acute diverticulitis in an emergency unit. *Scand J Gastroenterol.* 2015;50:536–541.
24. Bolkenstein HE, van de Wall BJ, Consten EC, van der Palen J, Broeders IA, Draaisma WA. Development and validation of a diagnostic prediction model distinguishing complicated from uncomplicated diverticulitis. *Scand J Gastroenterol.* 2018;53:1291–1297.
25. Alshamari M, Norrman E, Geijer M, Jansson K, Geijer H. Diagnostic accuracy of low-dose CT compared with abdominal radiography in non-traumatic acute abdominal pain: prospective study and systematic review. *Eur Radiol.* 2016;26:1766–1774.
26. Wasvary H, Turfah F, Kadro O, Beauregard W. Same hospitalization resection for acute diverticulitis. *Am Surg.* 1999;65:632–636.
27. Ambrosetti P. Acute diverticulitis of the left colon: value of the initial CT and timing of elective colectomy. *J Gastrointest Surg.* 2008;12:1318–1320.
28. Ambrosetti P, Becker C, Terrier F. Colonic diverticulitis: impact of imaging on surgical management – a prospective study of 542 patients. *Eur Radiol.* 2002;12:1145–1149.
29. Hall JF, Roberts PL, Ricciardi R, et al. Long-term follow-up after an initial episode of diverticulitis: what are the predictors of recurrence? *Dis Colon Rectum.* 2011;54:283–288.
30. Kameda T, Kawai F, Taniguchi N, Kobori Y. Usefulness of transabdominal ultrasonography in excluding adnexal disease. *J Med Ultrason (2001).* 2016;43:63–70.
31. Nielsen K, Richir MC, Stolk TT, et al. The limited role of ultrasound in the diagnostic process of colonic diverticulitis. *World J Surg.* 2014;38:1814–1818.
32. Schreyer AG, Layer G; German Society of Digestive and Metabolic Diseases (DGVS) as well as the German Society of General and Visceral Surgery (DGAV) in collaboration with the German Radiology Society (DRG). S2k guidlines for diverticular disease and diverticulitis: diagnosis, classification, and therapy for the radiologist. *Rofo.* 2015;187:676–684.
33. Dirks K, Calabrese E, Dietrich CF, et al. EFSUMB position paper: recommendations for gastrointestinal ultrasound (GIUS) in acute appendicitis and diverticulitis. *Ultraschall Med.* 2019;40:163–175.
34. Öistämö E, Hjern F, Blomqvist L, Von Heijne A, Abraham-Nordling M. Cancer and diverticulitis of the sigmoid colon. Differentiation with computed tomography versus magnetic resonance imaging: preliminary experiences. *Acta Radiol.* 2013;54:237–241.
35. Chabok A, Påhlman L, Hjern F, Haapaniemi S, Smedh K; AVOD Study Group. Randomized clinical trial of antibiotics in acute uncomplicated diverticulitis. *Br J Surg.* 2012;99:532–539.
36. Daniels L, Ünlü Ç, de Korte N, et al; Dutch Diverticular Disease (3D) Collaborative Study Group. Randomized clinical trial of observational versus antibiotic treatment for a first episode of CT-proven uncomplicated acute diverticulitis. *Br J Surg.* 2017;104:52–61. doi: 10.1002/bjs.10309
37. Mege D, Yeo H. Meta-analyses of current strategies to treat uncomplicated diverticulitis. *Dis Colon Rectum.* 2019;62:371–378.
38. Sánchez-Velázquez P, Grande L, Pera M. Outpatient treatment of uncomplicated diverticulitis: a systematic review. *Eur J Gastroenterol Hepatol.* 2016;28:622–627.
39. Isacson D, Smedh K, Nikberg M, Chabok A. Long-term follow-up of the AVOD randomized trial of antibiotic avoidance in uncomplicated diverticulitis. *Br J Surg.* 2019;106:1542–1548.
40. van Dijk ST, Daniels L, Ünlü Ç, et al; Dutch Diverticular Disease (3D) Collaborative Study Group. Long-term effects of omitting antibiotics in uncomplicated acute diverticulitis. *Am J Gastroenterol.* 2018;113:1045–1052.
41. Shabanzadeh DM, Wille-Jørgensen P. Antibiotics for uncomplicated diverticulitis. *Cochrane Database Syst Rev.* 2012;11:CD009092.
42. Estrada Ferrer O, Ruiz Edo N, Hidalgo Grau LA, et al. Selective non-antibiotic treatment in sigmoid diverticulitis: is it time to change the traditional approach? *Tech Coloproctol.* 2016;20:309–315.
43. Desai M, Fathallah J, Nutalapati V, Saligram S. Antibiotics versus no antibiotics for acute uncomplicated diverticulitis: a systematic review and meta-analysis. *Dis Colon Rectum.* 2019;62:1005–1012.
44. Au S, Aly EH. Treatment of uncomplicated acute diverticulitis without antibiotics: a systematic review and meta-analysis. *Dis Colon Rectum.* 2019;62:1533–1547.
45. Emile SH, Elfeki H, Sakr A, Shalaby M. Management of acute uncomplicated diverticulitis without antibiotics: a systematic review, meta-analysis, and meta-regression of predictors of treatment failure. *Tech Coloproctol.* 2018;22:499–509.
46. Mocanu V, Dang JT, Switzer N, et al. The role of antibiotics in acute uncomplicated diverticulitis: a systematic review and meta-analysis. *Am J Surg.* 2018;216:604–609.
47. Bolkenstein HE, Draaisma WA, van de Wall B, Consten E, Broeders I. Treatment of acute uncomplicated diverticulitis without antibiotics: risk factors for treatment failure. *Int J Colorectal Dis.* 2018;33:863–869.
48. Schug-Pass C, Geers P, Hügel O, Lippert H, Köckerling F. Prospective randomized trial comparing short-term antibiotic therapy versus standard therapy for acute uncomplicated sigmoid diverticulitis. *Int J Colorectal Dis.* 2010;25:751–759.
49. Biondo S, Golda T, Kreisler E, et al. Outpatient versus hospitalization management for uncomplicated diverticulitis: a prospective, multicenter randomized clinical trial (DIVER Trial). *Ann Surg.* 2014;259:38–44.
50. Gregersen R, Mortensen LQ, Burcharth J, Pommergaard HC, Rosenberg J. Treatment of patients with acute colonic diverticulitis complicated by abscess formation: a systematic review. *Int J Surg.* 2016;35:201–208.
51. Lambrichts DPV, Bolkenstein HE, van der Does DCHE, et al. Multicentre study of non-surgical management of diverticulitis with abscess formation. *Br J Surg.* 2019;106:458–466.
52. Aquina CT, Becerra AZ, Xu Z, et al. Population-based study of outcomes following an initial acute diverticular abscess. *Br J Surg.* 2019;106:467–476.
53. Brandt D, Gervaz P, Durmishi Y, Platon A, Morel P, Poletti PA. Percutaneous CT scan-guided drainage vs. antibiotherapy alone for Hinchey II diverticulitis: a case-control study. *Dis Colon Rectum.* 2006;49:1533–1538.
54. Elagili F, Stocchi L, Ozuner G, Kiran RP. Antibiotics alone instead of percutaneous drainage as initial treatment of large diverticular abscess. *Tech Coloproctol.* 2015;19:97–103.
55. Elagili F, Stocchi L, Ozuner G, Mody R, Baker ME, Kiran RP. Predictors of postoperative outcomes for patients with diverticular abscess initially treated with percutaneous drainage. *Am J Surg.* 2015;209:703–708.

56. Durmishi Y, Gervaz P, Brandt D, et al. Results from percutaneous drainage of Hinchey stage II diverticulitis guided by computed tomography scan. *Surg Endosc.* 2006;20:1129–1133.
57. Devaraj B, Liu W, Tatum J, Cologne K, Kaiser AM. Medically treated diverticular abscess associated with high risk of recurrence and disease complications. *Dis Colon Rectum.* 2016;59:208–215.
58. Garfinkle R, Kugler A, Pelsser V, et al. Diverticular abscess managed with long-term definitive nonoperative intent is safe. *Dis Colon Rectum.* 2016;59:648–655.
59. Toorenvliet BR, Swank H, Schoones JW, Hamming JF, Bemelman WA. Laparoscopic peritoneal lavage for perforated colonic diverticulitis: a systematic review. *Colorectal Dis.* 2010;12:862–867.
60. Strate LL, Morris AM. Epidemiology, pathophysiology, and treatment of diverticulitis. *Gastroenterology*. 2019;156:1282–1298.e1.
61. Schafmayer C, Harrison JW, Buch S, et al. Genome-wide association analysis of diverticular disease points towards neuromuscular, connective tissue and epithelial pathomechanisms. *Gut.* 2019;68:854–865.
62. Strate LL, Keeley BR, Cao Y, Wu K, Giovannucci EL, Chan AT. Western dietary pattern increases, and prudent dietary pattern decreases, risk of incident diverticulitis in a prospective cohort study. *Gastroenterology.* 2017;152:1023–1030.e2.
63. Liu PH, Cao Y, Keeley BR, et al. Adherence to a healthy lifestyle is associated with a lower risk of diverticulitis among men. *Am J Gastroenterol.* 2017;112:1868–1876.
64. Crowe FL, Balkwill A, Cairns BJ, et al; Million Women Study Collaborators; Million Women Study Collaborators. Source of dietary fibre and diverticular disease incidence: a prospective study of UK women. *Gut.* 2014;63:1450–1456.
65. Aune D, Sen A, Norat T, Riboli E. Dietary fibre intake and the risk of diverticular disease: a systematic review and meta-analysis of prospective studies. *Eur J Nutr*. 2020;59:421–432.
66. Stollman N, Smalley W, Hirano I; AGA Institute Clinical Guidelines Committee. American Gastroenterological Association Institute Guideline on the Management of Acute Diverticulitis. *Gastroenterology.* 2015;149:1944–1949.
67. Aune D, Sen A, Leitzmann MF, Tonstad S, Norat T, Vatten LJ. Tobacco smoking and the risk of diverticular disease - a systematic review and meta-analysis of prospective studies. *Colorectal Dis.* 2017;19:621–633.
68. Aune D, Sen A, Leitzmann MF, Norat T, Tonstad S, Vatten LJ. Body mass index and physical activity and the risk of diverticular disease: a systematic review and meta-analysis of prospective studies. *Eur J Nutr.* 2017;56:2423–2438.
69. Picchio M, Elisei W, Brandimarte G, et al. Mesalazine for the treatment of symptomatic uncomplicated diverticular disease of the colon and for primary prevention of diverticulitis: a systematic review of randomized clinical trials. *J Clin Gastroenterol.* 2016;50(suppl 1):S64–S69.
70. Picchio M, Elisei W, Tursi A. Mesalazine to treat symptomatic uncomplicated diverticular disease and to prevent acute diverticulitis occurrence. A systematic review with meta-analysis of randomized, placebo-controlled trials. *J Gastrointestin Liver Dis.* 2018;27:291–297.
71. Kruis W, Kardalinos V, Eisenbach T, et al. Randomised clinical trial: mesalazine versus placebo in the prevention of diverticulitis recurrence. *Aliment Pharmacol Ther.* 2017;46:282–291.
72. Khan MA, Ali B, Lee WM, Howden CW. Mesalamine does not help prevent recurrent acute colonic diverticulitis: meta-analysis of randomized, placebo-controlled trials. *Am J Gastroenterol.* 2016;111:579–581.
73. Carter F, Alsayb M, Marshall JK, Yuan Y. Mesalamine (5-ASA) for the prevention of recurrent diverticulitis. *Cochrane Database Syst Rev.* 2017;10:CD009839.
74. Lanas A, Ponce J, Bignamini A, Mearin F. One year intermittent rifaximin plus fibre supplementation vs. fibre supplementation alone to prevent diverticulitis recurrence: a proof-of-concept study. *Dig Liver Dis.* 2013;45:104–109.
75. Moniuszko A, Rydzewska G. The effect of cyclic rifaximin therapy on symptoms of diverticular disease from the perspective of the gastroenterology outpatient clinic: a "real-life" study. *Prz Gastroenterol.* 2017;12:145–151.
76. Bianchi M, Festa V, Moretti A, et al. Meta-analysis: long-term therapy with rifaximin in the management of uncomplicated diverticular disease. *Aliment Pharmacol Ther.* 2011;33:902–910.
77. Tursi A, Brandimarte G, Elisei W, et al. Randomised clinical trial: mesalazine and/or probiotics in maintaining remission of symptomatic uncomplicated diverticular disease–a double-blind, randomised, placebo-controlled study. *Aliment Pharmacol Ther.* 2013;38:741–751.
78. Suhardja TS, Norhadi S, Seah EZ, Rodgers-Wilson S. Is early colonoscopy after CT-diagnosed diverticulitis still necessary? *Int J Colorectal Dis.* 2017;32:485–489.
79. Sallinen V, Mentula P, Leppäniemi A. Risk of colon cancer after computed tomography-diagnosed acute diverticulitis: is routine colonoscopy necessary? *Surg Endosc.* 2014;28:961–966.
80. Sharma PV, Eglinton T, Hider P, Frizelle F. Systematic review and meta-analysis of the role of routine colonic evaluation after radiologically confirmed acute diverticulitis. *Ann Surg.* 2014;259:263–272.
81. Meyer J, Orci LA, Combescure C, et al. Risk of colorectal cancer in patients with acute diverticulitis: a systematic review and meta-analysis of observational studies. *Clin Gastroenterol Hepatol.* 2019;17:1448–1456.e17.
82. Lahat A, Yanai H, Menachem Y, Avidan B, Bar-Meir S. The feasibility and risk of early colonoscopy in acute diverticulitis: a prospective controlled study. *Endoscopy.* 2007;39:521–524.
83. Elmi A, Hedgire SS, Pargaonkar V, Cao K, McDermott S, Harisinghani M. Is early colonoscopy beneficial in patients with CT-diagnosed diverticulitis? *AJR Am J Roentgenol.* 2013;200:1269–1274.
84. Alexandersson BT, Hreinsson JP, Stefansson T, Jonasson JG, Bjornsson ES. The risk of colorectal cancer after an attack of uncomplicated diverticulitis. *Scand J Gastroenterol.* 2014;49:576–580.
85. Daniels L, Ünlü Ç, de Wijkerslooth TR, et al. Yield of colonoscopy after recent CT-proven uncomplicated acute diverticulitis: a comparative cohort study. *Surg Endosc.* 2015;29:2605–2613.
86. de Vries HS, Boerma D, Timmer R, van Ramshorst B, Dieleman LA, van Westreenen HL. Routine colonoscopy is not required in uncomplicated diverticulitis: a systematic review. *Surg Endosc.* 2014;28:2039–2047.
87. Ramphal W, Schreinemakers JM, Seerden TC, Crolla RM, Rijken AM, Gobardhan PD. What is the risk of colorectal cancer after an episode of acute diverticulitis in conservatively treated patients? *J Clin Gastroenterol.* 2016;50:e35–e39.
88. Walker AS, Bingham JR, Janssen KM, et al. Colonoscopy after Hinchey I and II left-sided diverticulitis: utility or futility? *Am J Surg.* 2016;212:837–843.

89. Rose J, Parina RP, Faiz O, Chang DC, Talamini MA. Long-term outcomes after initial presentation of diverticulitis. *Ann Surg.* 2015;262:1046–1053.
90. Trenti L, Kreisler E, Galvez A, Golda T, Frago R, Biondo S. Long-term evolution of acute colonic diverticulitis after successful medical treatment. *World J Surg.* 2015;39:266–274.
91. Jalouta T, Jrebi N, Luchtefeld M, Ogilvie JW Jr. Diverticulitis recurrence after percutaneous abscess drainage. *Int J Colorectal Dis.* 2017;32:1367–1373.
92. Lamb MN, Kaiser AM. Elective resection versus observation after nonoperative management of complicated diverticulitis with abscess: a systematic review and meta-analysis. *Dis Colon Rectum.* 2014;57:1430–1440.
93. Gaertner WB, Willis DJ, Madoff RD, et al. Percutaneous drainage of colonic diverticular abscess: is colon resection necessary? *Dis Colon Rectum.* 2013;56:622–626.
94. Li D, de Mestral C, Baxter NN, et al. Risk of readmission and emergency surgery following nonoperative management of colonic diverticulitis: a population-based analysis. *Ann Surg.* 2014;260:423–430.
95. Klarenbeek BR, Samuels M, van der Wal MA, van der Peet DL, Meijerink WJ, Cuesta MA. Indications for elective sigmoid resection in diverticular disease. *Ann Surg.* 2010;251:670–674.
96. Minardi AJ Jr, Johnson LW, Sehon JK, Zibari GB, McDonald JC. Diverticulitis in the young patient. *Am Surg.* 2001;67:458–461.
97. Cunningham MA, Davis JW, Kaups KL. Medical versus surgical management of diverticulitis in patients under age 40. *Am J Surg.* 1997;174:733–735.
98. Coble JL, Sheldon KE, Yue F, et al. Identification of a rare LAMB4 variant associated with familial diverticulitis through exome sequencing. *Hum Mol Genet.* 2017;26:3212–3220.
99. Katz LH, Guy DD, Lahat A, Gafter-Gvili A, Bar-Meir S. Diverticulitis in the young is not more aggressive than in the elderly, but it tends to recur more often: systematic review and meta-analysis. *J Gastroenterol Hepatol.* 2013;28:1274–1281.
100. van de Wall BJ, Draaisma WA, van Iersel JJ, Consten EC, Wiezer MJ, Broeders IA. Elective resection for ongoing diverticular disease significantly improves quality of life. *Dig Surg.* 2013;30:190–197.
101. El-Sayed C, Radley S, Mytton J, Evison F, Ward ST. Risk of recurrent disease and surgery following an admission for acute diverticulitis. *Dis Colon Rectum.* 2018;61:382–389.
102. Mathews SN, Lamm R, Yang J, et al. Factors associated with repeated health resource utilization in patients with diverticulitis. *J Gastrointest Surg.* 2017;21:112–120.
103. Hupfeld L, Burcharth J, Pommergaard HC, Rosenberg J. Risk factors for recurrence after acute colonic diverticulitis: a systematic review. *Int J Colorectal Dis.* 2017;32:611–622.
104. van de Wall BJ, Poerink JA, Draaisma WA, Reitsma JB, Consten EC, Broeders IA. Diverticulitis in young versus elderly patients: a meta-analysis. *Scand J Gastroenterol.* 2013;48:643–651.
105. Janes S, Meagher A, Frizelle FA. Elective surgery after acute diverticulitis. *Br J Surg.* 2005;92:133–142.
106. Anaya DA, Flum DR. Risk of emergency colectomy and colostomy in patients with diverticular disease. *Arch Surg.* 2005;140:681–685.
107. Simianu VV, Bastawrous AL, Billingham RP, et al. Addressing the appropriateness of elective colon resection for diverticulitis: a report from the SCOAP CERTAIN collaborative. *Ann Surg.* 2014;260:533–538.
108. Simianu VV, Strate LL, Billingham RP, et al. The impact of elective colon resection on rates of emergency surgery for diverticulitis. *Ann Surg.* 2016;263:123–129.
109. Morris AM, Regenbogen SE, Hardiman KM, Hendren S. Sigmoid diverticulitis: a systematic review. *JAMA.* 2014;311:287–297.
110. Ho VP, Nash GM, Milsom JW, Lee SW. Identification of diverticulitis patients at high risk for recurrence and poor outcomes. *J Trauma Acute Care Surg.* 2015;78:112–119.
111. Piessen G, Muscari F, Rivkine E, et al; FRENCH (Fédération de Recherche EN CHirurgie). Prevalence of and risk factors for morbidity after elective left colectomy: cancer vs noncomplicated diverticular disease. *Arch Surg.* 2011;146:1149–1155.
112. Li D, Baxter NN, McLeod RS, Moineddin R, Nathens AB. The decline of elective colectomy following diverticulitis: a population-based analysis. *Dis Colon Rectum.* 2016;59:332–339.
113. Boostrom SY, Wolff BG, Cima RR, Merchea A, Dozois EJ, Larson DW. Uncomplicated diverticulitis, more complicated than we thought. *J Gastrointest Surg.* 2012;16:1744–1749.
114. Forgione A, Leroy J, Cahill RA, et al. Prospective evaluation of functional outcome after laparoscopic sigmoid colectomy. *Ann Surg.* 2009;249:218–224.
115. van de Wall BJM, Stam MAW, Draaisma WA, et al; DIRECT trial collaborators. Surgery versus conservative management for recurrent and ongoing left-sided diverticulitis (DIRECT trial): an open-label, multicentre, randomised controlled trial. *Lancet Gastroenterol Hepatol.* 2017;2:13–22.
116. Bolkenstein HE, Consten ECJ, van der Palen J, et al; Dutch Diverticular Disease (3D) Collaborative Study Group. Long-term outcome of surgery versus conservative management for recurrent and ongoing complaints after an episode of diverticulitis: 5-year follow-up results of a multicenter randomized controlled trial (DIRECT-Trial). *Ann Surg.* 2019;269:612–620.
117. Bolkenstein HE, de Wit GA, Consten ECJ, Van de Wall BJM, Broeders IAMJ, Draaisma WA. Cost-effectiveness analysis of a multicentre randomized clinical trial comparing surgery with conservative management for recurrent and ongoing diverticulitis (DIRECT trial). *Br J Surg.* 2019;106:448–457.
118. van Dijk ST, Daniels L, de Korte N, et al; Dutch Diverticular Disease (3D) Collaborative Study Group. Quality of life and persistent symptoms after uncomplicated acute diverticulitis. *Dis Colon Rectum.* 2019;62:608–614.
119. Al-Khamis A, Abou Khalil J, Demian M, et al. Sigmoid colectomy for acute diverticulitis in immunosuppressed vs immunocompetent patients: outcomes from the ACS-NSQIP database. *Dis Colon Rectum.* 2016;59:101–109.
120. Biondo S, Borao JL, Kreisler E, et al. Recurrence and virulence of colonic diverticulitis in immunocompromised patients. *Am J Surg.* 2012;204:172–179.
121. Sugrue J, Lee J, Warner C, et al. Acute diverticulitis in renal transplant patients: should we treat them differently? *Surgery.* 2018;163:857–865.
122. Deery SE, Hodin RA. Management of diverticulitis in 2017. *J Gastrointest Surg.* 2017;21:1732–1741.
123. Ballian N, Rajamanickam V, Harms BA, et al. Predictors of mortality after emergent surgery for acute colonic diverticulitis: analysis of National Surgical Quality Improvement Project data. *J Trauma Acute Care Surg.* 2013;74:611–616.
124. Dharmarajan S, Hunt SR, Birnbaum EH, Fleshman JW, Mutch MG. The efficacy of nonoperative management of acute complicated diverticulitis. *Dis Colon Rectum.* 2011;54:663–671.

125. Binda GA, Karas JR, Serventi A, et al; Study Group on Diverticulitis. Primary anastomosis vs nonrestorative resection for perforated diverticulitis with peritonitis: a prematurely terminated randomized controlled trial. *Colorectal Dis.* 2012;14:1403–1410.
126. Oberkofler CE, Rickenbacher A, Raptis DA, 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;256:819–26 826.
127. Bridoux V, Regimbeau JM, Ouaissi M, et al. Hartmann's procedure or primary anastomosis for generalized peritonitis due to perforated diverticulitis: a prospective multicenter randomized trial (DIVERTI). *J Am Coll Surg.* 2017;225:798–805.
128. Lambrichts DPV, Vennix S, Musters GD, et al; LADIES trial collaborators. Hartmann's procedure versus sigmoidectomy with primary anastomosis for perforated diverticulitis with purulent or faecal peritonitis (LADIES): a multicentre, parallel-group, randomised, open-label, superiority trial. *Lancet Gastroenterol Hepatol.* 2019;4:599–610.
129. 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. *Colorectal Dis.* 2018;20:753–770.
130. Halim H, Askari A, Nunn R, Hollingshead J. Primary resection anastomosis versus Hartmann's procedure in Hinchey III and IV diverticulitis. *World J Emerg Surg.* 2019;14:32.
131. Acuna SA, Wood T, Chesney TR, et al. Operative strategies for perforated diverticulitis: a systematic review and meta-analysis. *Dis Colon Rectum.* 2018;61:1442–1453.
132. Vennix S, Musters G, Mulder I, et al. Laparoscopic peritoneal lavage or sigmoidectomy for perforated diverticulitis with purulent peritonitis: a multicentre, parallel-group, randomised, open-label trial. *Lancet.* 2015;386:1269–1277. doi: 10.1016/S0140-6736(15)61168-0.
133. Angenete E, Thornell A, Burcharth J, 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;263:117–122.
134. Schultz JK, Yaqub S, Wallon C, et al; SCANDIV Study Group. Laparoscopic lavage vs primary resection for acute perforated diverticulitis: the SCANDIV randomized clinical trial. *JAMA.* 2015;314:1364–1375.
135. Acuna SA, Dossa F, Baxter NN. The end of the Hartmann's era for perforated diverticulitis. *Lancet Gastroenterol Hepatol.* 2019;4:573–575.
136. Lee JM, Bai P Chang J, El Hechi M, et al. Hartmann's procedure vs primary anastomosis with diverting loop ileostomy for acute diverticulitis: nationwide analysis of 2,729 emergency surgery patients. *J Am Coll Surg.* 2019;229:48–55.
137. Tadlock MD, Karamanos E, Skiada D, et al. Emergency surgery for acute diverticulitis: which operation? A National Surgical Quality Improvement Program study. *J Trauma Acute Care Surg.* 2013;74:1385–1391.
138. Goldstone RN, Cauley CE, Chang DC, Kunitake H, Ricciardi R, Bordeianou L. The effect of surgical training and operative approach on outcomes in acute diverticulitis: should guidelines be revised? *Dis Colon Rectum.* 2019;62:71–78.
139. Golda T, Kreisler E, Mercader C, Frago R, Trenti L, Biondo S. Emergency surgery for perforated diverticulitis in the immunosuppressed patient. *Colorectal Dis.* 2014;16:723–731.
140. Cauley CE, Patel R, Bordeianou L. Use of primary anastomosis with diverting ileostomy in patients with acute diverticulitis requiring urgent operative intervention. *Dis Colon Rectum.* 2018;61:586–592.
141. Vermeulen J, Gosselink MP, Busschbach JJ, Lange JF. Avoiding or reversing Hartmann's procedure provides improved quality of life after perforated diverticulitis. *J Gastrointest Surg.* 2010;14:651–657.
142. Schultz JK, Wallon C, Blecic L, et al; SCANDIV Study Group. One-year results of the SCANDIV randomized clinical trial of laparoscopic lavage versus primary resection for acute perforated diverticulitis. *Br J Surg.* 2017;104:1382–1392.
143. Thornell A, Angenete E, Bisgaard T, et al. Laparoscopic lavage for perforated diverticulitis with purulent peritonitis: a randomized trial. *Ann Intern Med.* 2016;164:137–145.
144. Kohl A, Rosenberg J, Bock D, 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;105:1128–1134.
145. Vennix S, Musters GD, Mulder IM, et al; Ladies trial collaborators. Laparoscopic peritoneal lavage or sigmoidectomy for perforated diverticulitis with purulent peritonitis: a multicentre, parallel-group, randomised, open-label trial. *Lancet.* 2015;386:1269–1277.
146. 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;267:252–258.
147. Vennix S, van Dieren S, Opmeer BC, Lange JF, Bemelman WA. Cost analysis of laparoscopic lavage compared with sigmoid resection for perforated diverticulitis in the Ladies trial. *Br J Surg.* 2017;104:62–68.
148. Gervaz P, Ambrosetti P. Critical appraisal of laparoscopic lavage for Hinchey III diverticulitis. *World J Gastrointest Surg.* 2016;8:371–375.
149. Thaler K, Baig MK, Berho M, et al. Determinants of recurrence after sigmoid resection for uncomplicated diverticulitis. *Dis Colon Rectum.* 2003;46:385–388.
150. Benn PL, Wolff BG, Ilstrup DM. Level of anastomosis and recurrent colonic diverticulitis. *Am J Surg.* 1986;151:269–271.
151. Borchert DH, Schachtebeck M, Schoepe J, et al. Observational study on preservation of the superior rectal artery in sigmoid resection for diverticular disease. *Int J Surg.* 2015;21:45–50.
152. Lehmann RK, Brounts LR, Johnson EK, Rizzo JA, Steele SR. Does sacrifice of the inferior mesenteric artery or superior rectal artery affect anastomotic leak following sigmoidectomy for diverticulitis? a retrospective review. *Am J Surg.* 2011;201:623–627.
153. Cirocchi R, Trastulli S, Farinella E, et al. Is inferior mesenteric artery ligation during sigmoid colectomy for diverticular disease associated with increased anastomotic leakage? A meta-analysis of randomized and non-randomized clinical trials. *Colorectal Dis.* 2012;14:e521–e529.
154. Martinolich J, Croasdale DR, Bhakta AS, et al. Laparoscopic surgery for diverticular fistulas: outcomes of 111 consecutive cases at a single institution. *J Gastrointest Surg.* 2019;23:1015–1021.
155. Keller DS, Delaney CP, Hashemi L, Haas EM. A national evaluation of clinical and economic outcomes in open versus laparoscopic colorectal surgery. *Surg Endosc.* 2016;30:4220–4228.

156. Cirocchi R, Fearnhead N, Vettoretto N, et al. The role of emergency laparoscopic colectomy for complicated sigmoid diverticulits: a systematic review and meta-analysis. *Surgeon.* 2019;17:360–369.
157. Gralista P, Moris D, Vailas M, et al. Laparoscopic approach in colonic diverticulitis: dispelling myths and misperceptions. *Surg Laparosc Endosc Percutan Tech.* 2017;27:73–82.
158. Letarte F, Hallet J, Drolet S, et al. Laparoscopic emergency surgery for diverticular disease that failed medical treatment: a valuable option? Results of a retrospective comparative cohort study. *Dis Colon Rectum.* 2013;56:1395–1402.
159. Vennix S, Boersema GS, Buskens CJ, et al. Emergency laparoscopic sigmoidectomy for perforated diverticulitis with generalised peritonitis: a systematic review. *Dig Surg.* 2016;33:1–7.
160. Turley RS, Mantyh CR, Migaly J. Minimally invasive surgery for diverticulitis. *Tech Coloproctol.* 2013;17(suppl 1):S11–S22.
161. 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;56:72–82.
162. Beltzer C, Knoerzer L, Bachmann R, Axt S, Dippel H, Schmidt R. Robotic versus laparoscopic sigmoid resection for diverticular disease: a single-center experience of 106 cases. *J Laparoendosc Adv Surg Tech A.* 2019;29:1451–1455.
163. DeLeon M, Patel N, Chokhavatia S, Rezac C. Robotic surgery: advances in the treatment of diverticulitis. *Am J Gastroenterol.* 2014;109(suppl 2):S187–S222. doi:10.1038/ajg.2014.278.
164. Feinberg AE, Elnahas A, Bashir S, Cleghorn MC, Quereshy FA. Comparison of robotic and laparoscopic colorectal resections with respect to 30-day perioperative morbidity. *Can J Surg.* 2016;59:262–267.
165. Halabi WJ, Kang CY, Jafari MD, et al. Robotic-assisted colorectal surgery in the United States: a nationwide analysis of trends and outcomes. *World J Surg.* 2013;37:2782–2790.
166. Raskin ER, Keller DS, Gorrepati ML, Akiel-Fu S, Mehendale S, Cleary RK. Propensity-matched analysis of sigmoidectomies for diverticular disease. *JSLS.* 2019;23:23.
167. Ogilvie JW Jr, Saunders RN, Parker J, Luchtefeld MA. Sigmoidectomy for diverticulitis: a propensity-matched comparison of minimally invasive approaches. *J Surg Res.* 2019;243:434–439.
168. Al Natour RH, Obias V, Albright J, et al. A propensity score matched comparison of intracorporeal and extracorporeal techniques for robotic-assisted sigmoidectomy in an enhanced recovery pathway. *J Robot Surg.* 2019;13:649–656.